2005

WAPPAPELLO LAKE

WATER QUALITY

REPORT

U.S. ARMY CORPS OF ENGINEERS, ST. LOUIS DISTRICT
ENVIRONMENTAL QUALITY SECTION – WATER QUALITY

Table of Contents

Water Quality Report-Wappapello Lake

Section and Page No.

1.0 GENERAL OVERVIEW..pg. 1

2.0 WATER QUALITY ASSESSMENT CRITERIA ....pg. 3

3.0 SUMMARY OF MONITORING RESULTS..pg. 7

4.0 PLANNED 2006 STUDIES ....pg. 9

List of Figures & Tables

Figure 1: Lake Map..pg. 2

Table 2.1 State of Missouri - Water Quality Standards..pg. 3

Appendix

Appendix A: Data ....pg. A1-A6

Appendix B: Laboratory Data Graphs

Fecal Coliform ....pg. B1
Metals (Iron & Manganese)..pg. B2
Nitrogen (NH_3-N & NO_3-NO_2)...pg. B3
Orthophosphate & Total Phosphate.......................................pg. B4
Chlorophyll & Pheophytin...pg. B5
TSS & VSS ....pg. B6
TOC...pg. B7

Appendix C: Field Data Graphs

Temperature & DO ....pg. C1-C11
pH...pg. C12-C16
Redox & Conductivity ....pg. C17-C23
Secchi..pg. C24

WATER QUALITY MONITORING PROGRAM

1.0 GENERAL OVERVIEW

This report summarizes water quality activities of the St. Louis District for Fiscal Year 2005 in accordance with ER 1110-2-8154 Water Quality & Environmental management for Corps Civil Works Projects and ETL 1110-2-362 Environmental Engineering Initiatives for Water Management.

Water quality monitoring remains one of the Sections major responsibilities. The objective is to maintain a reasonable environmental monitoring program for the Mississippi River and the 5 lakes under the St. Louis District's control. The District's reservoirs consist of Mark Twain and Wappapello Lakes in Missouri, and Shelbyville, Carlyle and Rend Lakes in Illinois. Water quality sampling is conducted within the lakes and their tributaries to establish trend analysis and maintain water quality at or above state and federal regulations.

The main objective is to provide technical expertise of an environmental nature to all Corps elements requesting assistance in accordance with ER 1110-2-8154. This would include updating the water quality management priorities for the district's projects to ensure water quality meets the state and federal regulations, for protection of human health and the environment, and for the safety and economic welfare of those at Corps projects. Ongoing goals include ensuring that downstream water quality meets all state and federal regulations, is suitable for aquatic and human life, and continue to evaluate trend analysis in relation to baseline conditions at all projects.

1.1 INTRODUCTION

Wappapello Lake is located in southeastern Missouri and is primarily utilized as a recreational lake. The surrounding lands are residential with little agricultural use due to the terrain.

Nestled in the foothills of the Ozark Mountains, Wappapello Lake offers activities for all walks of life. Over 44,000 acres of public lands and water welcome hunting, fishing, swimming, boating, camping and picnicking. Interpretation of the natural resources through trails, Visitor Center exhibits and various programs highlight the natural beauty found in Southeast Missouri.

The operating purposes of Wappapello Lake are fishing, hunting and other wildlife activities as well as recreation uses, such as boating and swimming. The area around the lake has camping sites and nature trails. The water quality management program for the lake includes monitoring baseline parameters and ecological trends as well as investigating problem areas to keep the lake within state and federal standards.

The water quality monitoring program was conducted during 2005 at five lake sites to assure that safe conditions were maintained for human recreation, wildlife and aquatic life. One of the five sites was selected as a quality control duplicate site during each sampling event and was denoted as WAP-15. Sampling events took place three times from March through August

2005. The locations of the 5 sampling sites are depicted on the lake map in Figure 1.

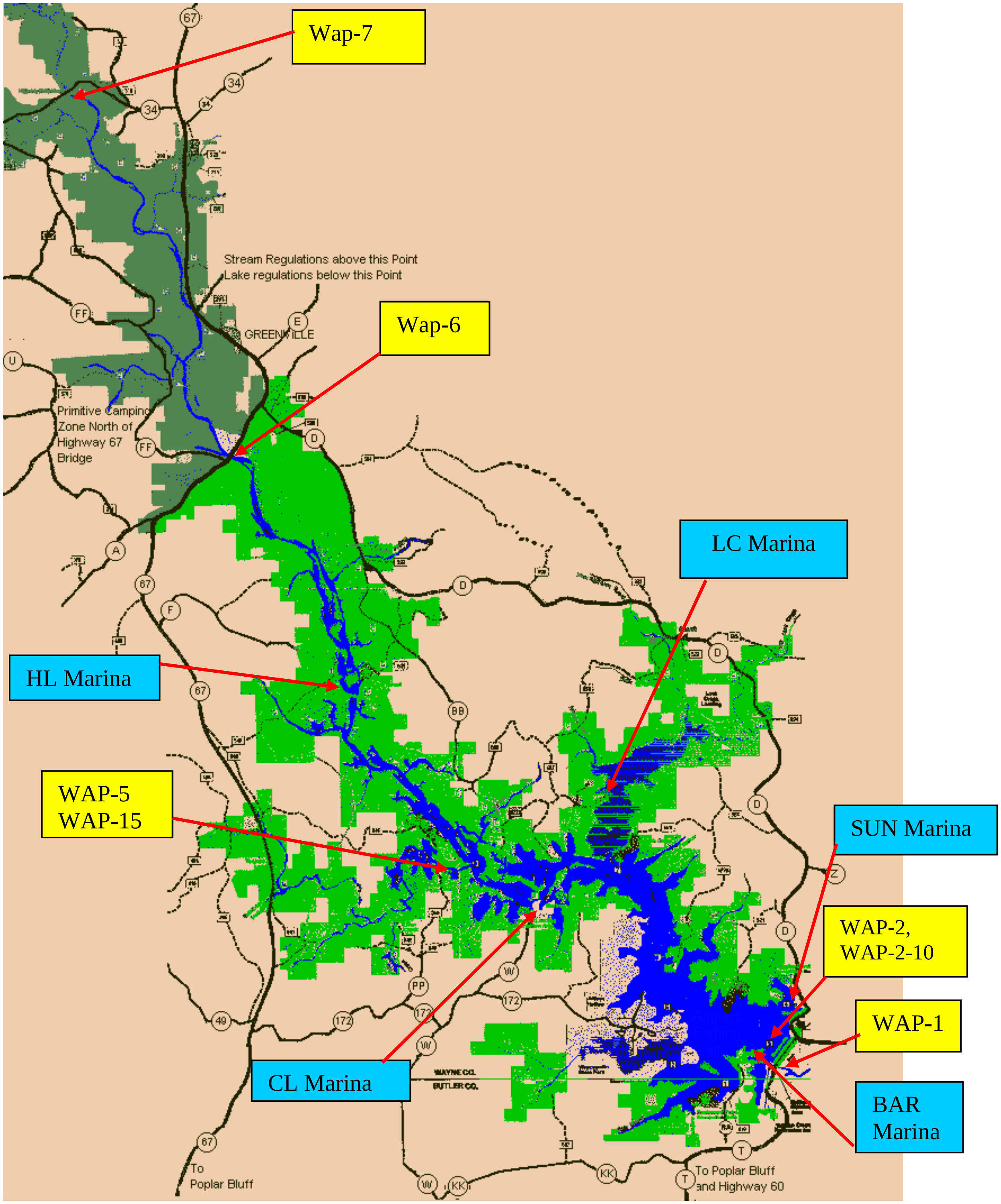


Figure 1
Location of sample sites

2.0 WATER QUALITY ASSESSMENT CRITERIA

The water quality assessment criteria were based upon the State of Missouri regulatory limits for certain contaminants, which has been generally accepted criteria for sustaining adequate aquatic plant and animal growth. The samplings and analysis which were conducted at the Wappapello Lake sites reflect the minimal set of parameters needed to analyze the current status of water quality for the Wappapello Lake system.

The following parameters were analyzed in the Fiscal Year 2005 samplings at Wappapello Lake: Total Organic Carbon (TOC), iron, manganese, ammonia-nitrogen, nitrate-nitrogen, orthophosphate, total phosphate, Total Suspended Solids (TSS), Total Volatile Suspended Solids (TVSS), fecal coliform, pH, temperature, dissolved oxygen, specific conductance, oxidation-reduction potential (ORP), chlorophyll, and pheophytin-a.

The Missouri Department of Natural Resources, Code of State Regulations, Division 20, Chapter 7 classifies water quality criteria based on designated usage. These standards are used to determine the aquatic water quality of the lake. Table 2.1 provides a listing of the regulatory limits for the parameters analyzed where a limit has been established.

TABLE 2.1

State of Missouri
Water Quality Standards

PARAMETER	LIMIT
Temperature	20.5^{o}C - 33^{o}C (68^{o}F - 90^{o}F)
Ammonia Nitrogen	< 15 mg/L
Nitrate Nitrogen	10 mg/L
Iron	1.0 mg/L (Aquatic Life)
Manganese	0.05 mg/L (Drinking Water & GW)
Phosphorous as Phosphate	0.05 mg/L
Fecal Coliform	< 200 colonies/100 ml
pH	Range: 6.5 to 9.0
DO	> 5.0 mg/L
Atrazine	0.003 mg/L (Drinking Water Standard)
Alachlor	0.002 mg/L (Drinking Water Standard)

Nitrogen is an essential component of proteins, genetic material, chlorophyll, and other key organic molecules. All organisms require nitrogen in order to survive. Nitrogen exists in several forms. These forms include gaseous nitrogen (N_2), nitrites (NO_2), nitrate (NO_3), ammonia nitrogen (NH_3-N), and ammonium (NH_4). Ammonia can be toxic to fish and other aquatic organisms at certain levels. Unlike ammonia, ammonium (NH4) is not toxic to aquatic organisms and is readily available for uptake by plankton and macrophytes. Nitrogen levels have increased as human activities have accelerated the rate of fixed nitrogen being put into circulation. High nitrogen levels can cause eutrophication. Eutrophication increases biomass of phytoplankton, decrease water transparency, and causes oxygen depletion. Ammonia nitrogen is monitored so that the effects on fish spawning, hatching, growth rate and pathologic changes in gills, liver and kidney tissue can be related to the detected levels of ammonia nitrogen. Nitrate-nitrogen degrades to nitrite or produces ammonia which has a detrimental effect on aquatic life and, therefore, has been monitored to assure levels are below the regulatory "safe" limit.

Phosphate has been analyzed as phosphorus and has been monitored due to the potential for uptake by nuisance algae. Levels of phosphate can indicate the potential for rapid growth of algae (algae bloom) which can cause serious oxygen depletion during the algae decay process. Phosphorous is typically the limiting nutrient in a water body. Therefore, addition of phosphorous to the ecosystem stimulates the growth of plants and algae. Phosphorous is delivered to lakes and streams by way of storm water runoff from agricultural fields, residential property, and construction sites. Other sources of phosphorous are anaerobic decomposition of organic matter, leaking sewer systems, waterfowl, and point source pollution. The general standard for phosphorous in lake water is 0.05mg/L. Dissolved phosphorous also called ortho-phosphorous is generally found in much smaller concentrations than total phosphorous and is readily available for uptake. For this reason dissolved phosphorous concentrations are variable and difficult to use as an indicator of nutrient availability.

The metals manganese and iron are nutrients for both plants and animals. Living organisms require trace amounts of metals. However, excessive amounts can be harmful to the organism. Heavy metals exist in surface waters in three forms, colloidal, particulate, and dissolved. Water chemistry determines the rate of adsorption and desorption of metals to and from sediment. Metals are desorbed from the sediment if the water experiences increases in salinity, decreases in redox potential, or decreases in pH. Metals in surface waters can be from natural or human sources. Currently human sources contribute more metals than natural sources. Metals levels in surface water may pose a health risk to humans and the environment.

Photosynthetic activity can be hindered by the levels of total suspended solids. Total suspended solids concentrations, which cause the photosynthetic activity to be reduced by more than 10% from the seasonably established norm, can have a detrimental effect on aquatic life. Soil particles, organic material, and other debris comprise suspended solids in the water column. Secchi disk measurements are inverse to suspended solid measurements. As the total suspended solids (TSS) increase, the secchi disk depth or water transparency decreases. Total suspended solids can be an important indicator of the type and degree of turbidity. TSS measurements represent a combination of organic (volatile) and inorganic (non-volatile) particles in the water. In order to more accurately determine the types and amounts of suspended solids, volatile suspended solids (VSS) are analyzed. VSS concentration represents the organic portion of the total suspended solids. Organic material often includes plankton and additional plant and animal debris that is present in water. Total volatile solids indicate the presence of organics in suspension and, therefore, show additional demand levels of oxygen.

Chlorophyll and pheophytin-a are monitored to provide indicators of algae growth and, therefore, potential oxygen depletion activity. Chlorophyll is measured in lakes to estimate the type and amount of algal productivity in the water column. Chlorophyll a is present in green algae, blue-green algae, and in diatoms. Chlorophyll a is often used to indicate the degree of eutrophication. Chlorophyll b and c are used to estimate the extent of algal diversity and productivity. Chlorophyll b is common in green algae and is used as an auxiliary pigment for photosynthesis. Chlorophyll c is most common in diatom species and serves as an auxiliary pigment. Algal productivity and diversity can be determined by the concentrations of the individual pigments. For example high concentrations of chlorophyll a and b would indicate that green algae is abundant. High concentrations of chlorophyll a would indicate abundance of blue-green algae and concentrations of chlorophyll a and c would indicate diatoms are the dominant species. Chlorophyll production is currently being connected with hypoxia.

Fecal coliform bacteria is monitored for the protection of human health as it relates to full body contact of recreational waters. People can be exposed to disease-causing organisms, such as bacteria, viruses and protozoa in beach and recreational waters mainly through accidental ingestion of contaminated water or through skin contact. These organisms, called pathogens, usually come from the feces of humans and other warm-blooded animals. If taken into the body, pathogens can cause various illnesses and on rare occasions, even death. Waterborne illnesses include diseases resulting from bacteria infection such as cholera, salmonellosis, and gastroenteritis, viral infections such as hepatitis, gastroenteritis, and intestinal diseases, and protozoan infections such as ameobic dysentery and giardiasis. The most commonly monitored recreational water indicator organisms are fecal coliform, Escherichia coli, (E. coli) and enterococci. Fecal coliform are bacteria that live in the intestinal tracts of warm-blooded animals. The standard for fecal coliform is less than 200 colonies per 100ml of sample water. Fecal coliform was originally recommended in 1968 by the Federal Water Pollution Control Administration (predecessor to EPA) as an effective water quality indicator organism for recreational waters. Recent studies indicate that fecal coliform show less correlation to illness than other indicator organisms such as E. coli and enterococci. The Environmental Protection Agency (EPA) currently recommends E. coli or enterococci as an indicator organism for fresh waters. Although E. coli and enterococci are more costly they may become the standard in the near furure.

Atrazine and Alachlor herbicides are commonly used agricultural chemicals which can be readily transported by rainfall runoff. Both compounds are suspected of causing cancer and, therefore, were monitored for the protection of human and aquatic health. Organic compounds include many pesticides. A pesticide can be any substance that is intended to prevent, destroy, repel, or mitigate any pest. This includes insecticides, herbicides, fungicides, fumigants, algaecides and other substances. Herbicides which are pesticides used to kill vegetation are the most widely used and sampled. Ten of the most frequently used herbicides and detected in water are Atrazine, Metolachlor, Alachlor, 2,4-D, Trifluralin, Glyphosate, Dicamba, Cyanazine, Simazine, and 2,4,5-T. Two of the most widely used pesticides are Atrazine and Alachlor. Atrazine is a preemergence or postemergence herbicide use to control broadleaf weeds and annual grasses. Atrazine is most commonly detected in ground and surface water due to its wide use, and its ability to persist in soil and move in water. Alachlor is a Restricted Use Pesticide (RUP) due to the potential to contaminate groundwater. The drinking water standard for Atrazine is 0.003mg/L and 0.002 mg/L for Alachlor.

Temperature, dissolved oxygen and pH are monitored for the protection of aquatic life. Temperature is important because it controls several aspects of water quality. Colder water hold more dissolved oxygen which is required by aquatic organisms. Plants grow more rapidly and use more oxygen in warmer water. Decomposition of organic matter which uses oxygen is accelerated in warmer water. Temperature can also determine the availability of toxic compounds such as ammonia. Since aquatic organisms are cold blooded, water temperature regulates their metabolism and ability to survive. The number and kinds of organisms that are found in streams or lakes is directly related to temperature. Certain organisms require a specific temperature range, such as trout, which require water temperatures below 20^{o}C. Most aquatic organisms require a minimum concentration of dissolved oxygen to survive. In spring, surface waters of the lake mix with the water below through wind and thermal action. This mixing diminishes as the upper layer of water becomes warmer and less dense. Solar insulation during the summer months stratifies the lake into three zones. The upper warmer water zone is called the epilimnion and the lower cooler water zone is called the hypolimnion. The epilimnion and the hypolimnion zones are divided by a transition zone known as the metalimnion. The thermocline located within the metalimnion exhibits a rapid change in water temperature. During the summer months the hypolimnion may become anaerobic. In this anaerobic zone, chemical reduction of iron and manganese, or the production of methane and sulfides can occur. Iron rapidly oxidizes in aerobic environments, but manganese oxidizes slowly and can remain in the reduced state for long distances down stream even in aerobic environments. The degree of acidity of water is measured by a logarithmetic scale ranging from 0 to 14 and is known as the pH scale. A reading of 7 indicates neutrality and readings below seven are acidic and above are alkaline. Most Illinois lakes range from 6 to 9 on the pH scale. The buffering capacity of water is the ability to neutralize acid better known as alkalinity. A high alkalinity concentration indicates an increased ability to neutralize pH and resist changes, whereas a low alkalinity concentration indicates that a water body is vulnerable to changes in pH.

Conductivity is a measure of a water's ability to conduct an electrical current. The ability to carry a current is often driven by the dissolved materials present in a water column. These materials can include dissolved ions and other materials in the water and thus are directly proportional to the concentration of total dissolved solids (TDS) present in the water column. Typically TDS concentrations represent 50-60% of the conductivity measurements.

Redox or Oxidation-Reduction Potential (ORP) is a measurement to oxidize materials. Oxidation involves an exchange of electrons between 2 atoms. The atom that loses an electron is oxidized and the one that gains an electron is reduced. ORP sensors measure the electrochemical potential between the solution and a reference electrode. Readings are expressed in millivolts with positive readings indicating increased oxidizing potential and negative readings being increased reduction. The ORP probe is essentially a millivolt meter, measuring the voltage across 2 electrodes with the water in between.

Water clarity is intuitively used by the public to judge water quality. Secchi depth has been used for many years as a limnological characterization tool for characterizing water clarity. Secchi depth is a measure of light penetration into a waterbody and is a function of the absorption and scattering of light in the water. There are three characteristics of water which affect the penetration of light. The three factors are the color of water, amount of phytoplankton in the water column, and amount of inorganic material in the water column. Secchi depth integrates the combined impacts of all the factors which influence water clarity. Water transparency was measured using a Secchi disk. Secchi disk readings were taken at all lake sites.

3.0 SUMMARY OF MONITORING RESULTS

The seasonal change brought on gradual lake stratification during the summer months. Fecal coli are sampled at the marinas to ensure that the marina areas are not being contaminated by boats with restroom facilities. Bacteria levels for all the marinas were below the Missouri standard of 200 colonies/100ml of sample.

Total iron and total manganese are sampled above the dam near the bottom of the channel (WAP-2-10), and in the spillway area (WAP-1). As was previously stated living organisms require trace amounts of metals, however excessive amounts can be harmful to the organism. Iron exceeded the Missouri Water Quality Standard at site WAP-2-10 for the August sampling event. Iron cycling is a function of oxidation-reduction processes. This elevated level of iron near the bottom of the lake is not detrimental to the overall lake system at this time. Iron oxidizes relatively rapidly (minutes to hours); therefore any iron released through the spillway will normally be oxidized in a short period of time. Missouri's standard for manganese is for drinking water and groundwater. Missouri does not have a manganese standard for aquatic life.

Nitrogen and phosphates are sampled at all sites. The 2005 phosphate results at all sites exceeded or nearly exceeded the 0.05 mg/L standard, with the highest readings normally occurring in August. Because phosphorous in water is not considered directly toxic to humans and animals no drinking water standards have been established for phosphorous. However, phosphorous can cause health threats through the stimulation of toxic algal blooms and the resulting oxygen depletion. However, nitrates can pose a threat to human and animal health. Nitrate in water is toxic at high levels and has been linked to toxic effects of livestock and to blue baby disease (methemoglobinemia) in infants. The Maximum Contaminant Level (MCL) for nitrate-N in drinking water is 10mg/L to protect babies 3 to 6 months of age. The Missouri Water Quality Standard for ammonia nitrogen (NH_3-N) is 15mg/L. The increased levels of phosphate in combination with nitrogen and other lake conditions, such as temperature, pH and stagnant lake conditions, can lead to increased algae growth. Eutrophication is currently the most widespread water quality problem in the U.S. and many other countries. Restoration of eutrophic waters requires the reduction of nonpoint inputs of phosphorous and nitrogen. The resulting detrimental effects of algae toxins and oxygen depletion could result in health problems for fish and other aquatic species as well as land animals utilizing the water supply. There were no signs of any of these effects throughout 2005.

Chlorophyll *a* was sampled at 3 sites, WAP-2, WAP-5, WAP-6 and WAP15. WAP-15 is a duplicate sample of WAP-5. Chlorophyll a is a green pigment found in plants. Chlorophyll *a* concentrations are an indicator of phytoplankton abundance and biomass. They can be an effective measure of trophic status, and used as a measure of water quality. High levels often indicate poor water quality and low levels suggest good conditions. However, elevated levels are not necessarily bad. It is the long term persistence of elevated levels that is the problem. It is natural for chlorophyll *a* levels to fluctuate over time. Chlorophyll *a* tends to be higher after storm events and during the summer months when water temperatures and light levels are elevated. Chlorophyll can reduce the clarity of the water and the amount of oxygen available to other organisms. Missouri does not currently have a standard for chlorophyll. The data indicates a normal increase in chlorophyll levels during the warmer summer months, which is not a concern.

Due to the limited amount of agriculture in the Wappapello watershed and the government chemical restrictions on the use of Atrazine and Alachlor on leased cropland, these chemicals were not sampled.

Total Suspended Solids (TSS) and Total Volatile Suspended Solids (TVSS) samples are collected at all sites. Solids can affect water quality by increasing temperature through the absorption of sunlight by the particles in the water, which also effects the clarity of the water. This can then effect the amount of oxygen in the water. Missouri does not currently have a standard for TSS or TVSS.

Total Organic Carbon (TOC) is collected at all sites. TOC is an indicator of the organic character of water. The larger the carbon or organic content, the more oxygen is consumed. TOC tends to be higher in the summer months which may be a result of plant material, which had grown all summer and begins to decay. Missouri does not currently have a standard for TOC.

Temperature and dissolved oxygen levels were taken at all sites. Measurements were taken at 1 meter intervals at the lake sites. During the summer months the lake stratifies and a boundary is formed between the upper warmer water and the lower cooler water. This transition area is known as the thermocline, the area where the temperature drops significantly. Oxygen levels can also change drastically as a function of depth. This area where the oxygen level significantly drops is called the oxycline. The depth of the thermocline and oxycline can have an effect on the aquatic organisms. Occasionally the thermocline and oxycline are at or near the same depth.

PH is taken at all sites and at 1 meter intervals at lake sites. All sites were within the 6 to 9 pH range.

Conductivity and redox are taken at all sites and at 1 meter intervals at lake sites. Missouri does not currently have a standard for conductivity or redox.

The monitoring program for Wappapello Lake during Fiscal Year 2005 revealed good water quality when compared to limits established by the Missouri Department of Natural Resources for general use, secondary contact, and indigenous aquatic life. Nutrient runoffs were primary concerns for the lake’s water quality. Better land management practices, erosion control and buffering zones are methods used to reduce such contaminants from entering the lake. The St. Louis District personnel have been working continuously with lake personnel, area communities and other agencies in the implementation of educational programs and implementation planning to bring about the use of better management techniques to improve the lake’s water quality.

4.0 PLANNED 2006 STUDIES

The Wappapello Lake water quality monitoring will continue in Fiscal Year 2006. A total of five sampling events will be conducted between February and September in 2006. Wappapello Lake is a high usage recreational lake. The monitoring of water quality is imperative to assure the water quality is within acceptable limits for the designated usage.

The sampling plan will involve an intensive trend analysis of the contaminants entering Wappapello Lake. The sampling sites include the following: WAP-1 Spillway, WAP-2 lake side of dam, WAP-5 Otter Creek, WAP-6 Greenville, WAP-7 Hwy 34 bridge and all 5 marinas. This combination of sites effectively represents the incoming contaminants and their effects on the lake.

APPENDIX A

DATA

LAB DATA

SITE	DEPTH (m)	DATE	TIME	TOC (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	NH_3N (mg/L)	NO_{3-} NO_2 (mg/L)	Ortho-phosphate (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Volatile Suspended Solids (mg/L)
WAP-1	0	3/15/2005	1242	5.0	0.34	0.10	0.03	0.02	0.01	0.05	10	2
WAP-1	0	5/5/2005	1220	5.0	0.34	0.11	0.09	0.02	0.01	0.09	12	3
WAP-1	0	8/23/2005	1243	8.9	0.44	0.85	0.28	0.16	0.02	0.10	14	6
WAP-2-0	0	3/15/2005	1136	5.0			0.03	0.02	0.01	0.05	11	4
WAP-2-0	0	5/5/2005	1154	5.0			0.04	0.02	0.01	0.03	6	2
WAP-2-0	0	8/23/2005	1132	6.1			0.41	0.32	0.06	0.07	9	5
WAP-2-10	10	3/15/2005	1131	5.0	0.37	0.10	0.03	0.02	0.01	0.05	13	3
WAP-2-10	10	5/5/2005	1150	5.0	0.45	0.16	0.11	0.02	0.01	0.09	15	3
WAP-2-10	10	8/23/2005	1128	5.0	1.80	3.10	1.20	0.04	0.10	0.18	13	4
WAP-5	0	3/15/2005	1100	5.0			0.03	0.02	0.01	0.12	26	5
WAP-5	0	5/5/2005	1114	5.0			0.06	0.02	0.01	0.05	7	2
WAP-5	0	8/23/2005	1323	5.0			0.03	0.02	0.03	0.07	12	4
WAP-6-0	0	3/15/2005	1028	5.0			0.03	0.04	0.01	0.02	1	1
WAP-6-0	0	5/5/2005	1040	5.0			0.09	0.04	0.01	0.03	5	1
WAP-6-0	0	8/23/2005	1012	5.0			0.05	0.24	0.03	0.08	7	1
WAP-7	0	3/15/2005	0950	5.0			0.03	0.04	0.01	0.01	1	1
WAP-7	0	5/5/2005	1000	5.0			0.07	0.02	0.01	0.03	2	1
WAP-7	0	8/23/2005	0930	5.0			0.06	0.21	0.03	0.05	10	1
WAP-15-0	0	3/15/2005	1107	5.0			0.03	0.03	0.01	0.12	24	3
WAP-15-0	0	5/5/2005	1117	5.0			0.05	0.02	0.01	0.05	10	2
WAP-15-0	0	8/23/2005	1328	5.0			0.05	0.07	0.01	0.05	11	3

LAB DATA

SITE	DEPTH	DATE	TIME	Chlorophyll (mg/m^3)	Pheophytin (mg/m3)
WAP-1	0	3/15/2005	1242		
WAP-1	0	5/5/2005	1220		
WAP-1	0	8/23/2005	1243		
WAP-2-0	0	3/15/2005	1136	5.0	5.0
WAP-2-0	0	5/5/2005	1154	5.0	5.0
WAP-2-0	0	8/23/2005	1132	32.8	5.0
WAP-2-10	10	3/15/2005	1131		
WAP-2-10	10	5/5/2005	1150		
WAP-2-10	10	8/23/2005	1128		
WAP-5	0	3/15/2005	1100	6.7	5.0
WAP-5	0	5/5/2005	1114	5.0	5.0
WAP-5	0	8/23/2005	1323	9.8	5.0
WAP-6-0	0	3/15/2005	1028	5.0	5.0
WAP-6-0	0	5/5/2005	1040	5.0	5.0
WAP-6-0	0	8/23/2005	1012	5.0	5.0
WAP-7	0	3/15/2005	0950		
WAP-7	0	5/5/2005	1000		
WAP-7	0	8/23/2005	0930		
WAP-15-0	0	3/15/2005	1107	6.7	5.0
WAP-15-0	0	5/5/2005	1117	5.0	5.0
WAP-15-0	0	8/23/2005	1328	9.7	5.0

LAB DATA

Site	Depth	Date	Time	FECALCOL (colonies/100ml)
HL-MARINA	0	5/5/2005	1047	2
HL-MARINA	0	8/23/2005	1030	2
CL-MARINA	0	5/5/2005	1132	20
CL-MARINA	0	8/23/2005	1043	20
LC-MARINA	0	5/5/2005	1140	2
LC-MARINA	0	8/23/2005	1055	12
SUN-MARINA	0	5/5/2005	1202	2
SUN-MARINA	0	8/23/2005	1200	10
BAR-MARINA	0	5/5/2005	1145	2
BAR-MARINA	0	8/23/2005	1120	14

FIELD DATA

Site	Date	Depth	H2OTemp (^oC)	Redox (mV)	Cond (uS/cm)	pH	D.0.%	D.O.(mg/L)	Time	Seechi (in)	Air Temp (^oF)	Weather	Wind
WAP-1	3/15/2005	0.529	8.93	332	244	8.00	113.0	13.14	1242				
WAP-1	5/5/2005	0.57	18.12	205.4	218	8.13	120.0	12.6	1220				
WAP-1	8/23/2005	0.838	28.58	-75.3	234	7.99	98.4	7.62	1243		79		
WAP-2	3/15/2005	0.60	8.86	336	250	8.00	112.6	13.01	1136	**22**			
WAP-2	3/15/2005	1.00	8.88	339	250	7.98	110.0	12.78	1138				
WAP-2	3/15/2005	2.00	8.9	339	249	7.98	109.0	12.70	1139				
WAP-2	3/15/2005	3.00	8.9	339	249	7.90	109.0	12.66	1140				
WAP-2	3/15/2005	4.00	8.84	339	246	7.97	108.0	12.60	1141				
WAP-2	3/15/2005	5.00	8.11	338	245	7.95	108.0	12.56	1141				
WAP-2	3/15/2005	6.00	8.73	338	243	7.94	107.0	12.46	1142				
WAP-2	3/15/2005	7.00	8.75	337	242	7.95	107.0	12.45	1145				
WAP-2	3/15/2005	8.00	8.74	336	242	7.94	109.0	12.67	1146				
WAP-2	3/15/2005	9.00	8.73	335	243	7.92	93.6	10.56	1147				
WAP-2	5/5/2005	0.67	18.25	133	217	8.41	138.2	13	1154	40			
WAP-2	5/5/2005	1.67	17.61	133.2	216	8.45	137.7	13.17	1156				
WAP-2	5/5/2005	2.17	17.1	135.4	215	8.3	131.6	12.6	1158				
WAP-2	5/5/2005	3.1	16.36	139	218	8.19	123.2	11.8	1200				
WAP-2	5/5/2005	4.09	16.35	142.4	216	8.07	117	11.3	1202				
WAP-2	5/5/2005	5	16.57	145.3	219	7.96	112.7	11.2	1204				
WAP-2	5/5/2005	6.2	16.37	149.4	217	7.79	98	9.57	1206				
WAP-2	5/5/2005	7.15	16.38	152.9	218	7.73	92.6	9.08	1208				
WAP-2	5/5/2005	8.02	16.03	154.4	218	7.71	91.3	8.94	1210				
WAP-2	5/5/2005	9.1	16.28	156.4	218	7.68	89.7	8.99	1212				
WAP-2	5/5/2005	10.36	16.28	159.1	219	7.55	87.6	8.57	1215				
WAP-2	8/23/2005	0.013	30.20	93.0	205	8.62	118.1	8.89	1132	18	75		
WAP-2	8/23/2005	1	29.62	95.6	207	8.53	97.6	7.38	1134		75		
WAP-2	8/23/2005	2	29.55	96.6	207	8.49	89.7	6.83	1136		75		
WAP-2	8/23/2005	3	29.36	102.9	211	8.28	60.4	4.60	1138		75		
WAP-2	8/23/2005	4	27.11	-243.7	249	7.59	10.5	0.81	1140		75		
WAP-2	8/23/2005	5	25.24	-289.9	279	7.30	7.9	0.65	1141		75		
WAP-2	8/23/2005	6	22.98	-295.0	303	7.17	7.8	0.67	1142		75		

FIELD DATA

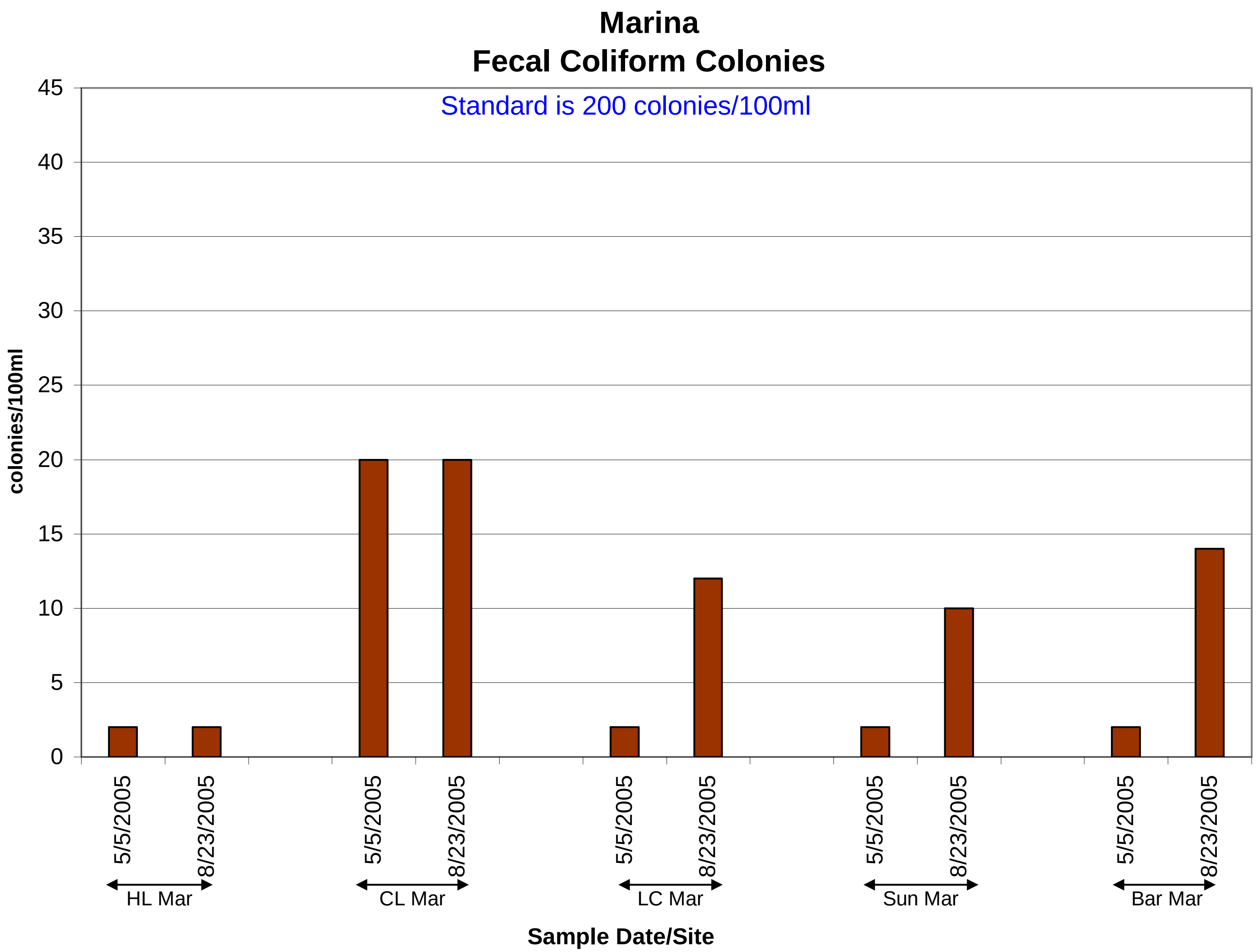
Site	Date	Depth	H2OTemp (°C)	Redox (mV)	Cond (uS/cm)	pH	D.0.%	D.O.(mg/L)	Time	Seechi (in)	Air Temp (°F)	Weather	Wind
WAP-2	8/23/2005	7	22.07	-296.4	310	7.10	8.0	0.70	1143		75		
WAP-2	8/23/2005	8	21.45	-296.9	316	7.03	8.1	0.72	1144		75		
WAP-2	8/23/2005	9	21.29	-298.2	318	6.98	8.1	0.72	1145		75		
WAP-2	8/23/2005	10	21.00	-294.3	328	6.91	8.0	0.71	1146		76		
WAP-5	3/15/2005	0.67	8.73	363	234	7.77	109.0	12.75	1100	**11**		cloudy	light
WAP-5	3/15/2005	1.00	8.56	355	228	7.71	105.0	12.28	1102				
WAP-5	3/15/2005	2.00	8.39	351	230	7.67	93.8	11.34	1103				
WAP-5	5/5/2005	0.4	18.96	221.1	214	8.11	131.7	12.2	1114	25			
WAP-5	5/5/2005	1	17.06	219.2	213	8.15	134	12.52	1116				
WAP-5	5/5/2005	2	16.53	220.8	208	7.87	122.5	11.93	1118				
WAP-5	5/5/2005	3.1	15.37	225.4	197	7.48	76.4	7.65	1120				
WAP-5	5/5/2005	4.39	16	239	198	7.38	49.0	4.07	1122				
WAP-5	8/23/2005	0.17	30.96	43.4	262	7.86	103.6	7.68	1323	18	80		
WAP-5	8/23/2005	1	29.34	58.9	258	7.66	76.7	5.83	1325		80		
WAP-5	8/23/2005	2	28.87	68.4	252	7.48	55.2	4.22	1327		80		
WAP-5	8/23/2005	3	28.37	65.1	271	7.26	12.7	0.99	1329		81		
WAP-6	3/15/2005	0.87	8.22	342	296	7.75	107.0	12.58	1028	9		cloudy	light
WAP-6	3/15/2005	2.00	8.21	349	293	7.68	105.0	12.40	1030			cloudy	light
WAP-6	3/15/2005	3.00	8.23	351	293	7.65	104.0	12.32	1033				
WAP-6	5/5/2005	0.58	15.51	275.2	224	7.91	115.9	11.57	1040	7			
WAP-6	5/5/2005	1.15	15.33	275.9	223	7.83	113.9	11.37	1041				
WAP-6	5/5/2005	2.04	15.3	276.4	223	7.82	112.9	11.31	1042				
WAP-6	5/5/2005	3.1	15.23	276.6	223	7.81	112.3	11.27	1043				
WAP-6	5/5/2005	4.09	15.22	276.8	223	7.81	112.1	11.24	1044				

FIELD DATA

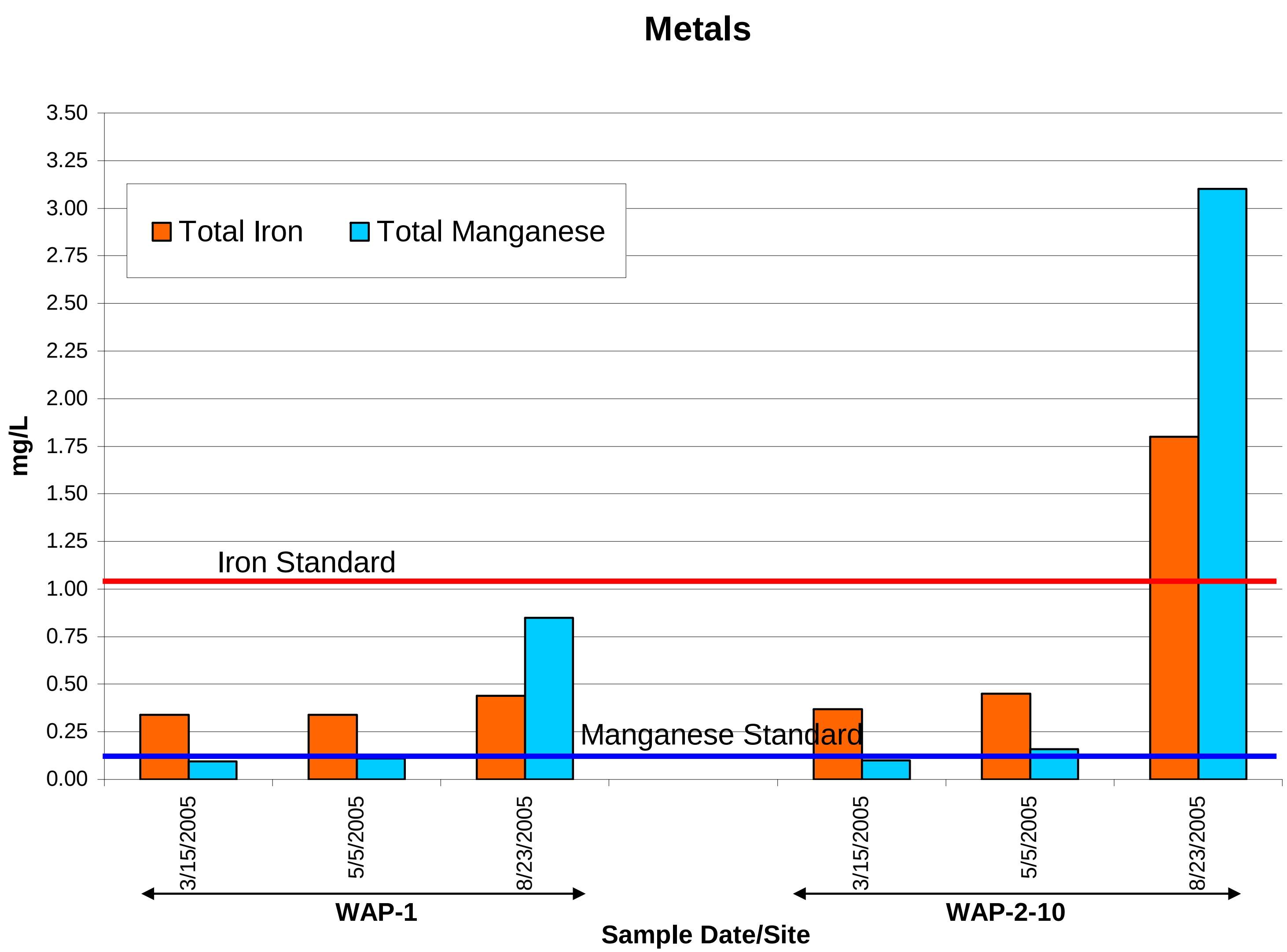
Site	Date	Depth	H2OTemp (^oC)	Redox (mV)	Cond (uS/cm)	pH	D.0.%	D.O.(mg/L)	Time	Seechi (in)	Air Temp (^oF)	Weather	Wind
WAP-6	8/23/2005	0.181	27.15	217.3	216	7.57	86.4	6.8	1012	34	73		
WAP-6	8/23/2005	1	27.03	211.7	216	7.45	81.2	6.47	1013		73		
WAP-6	8/23/2005	2	25.56	203.9	215	7.37	78.7	6.45	1015		73		
WAP-6	8/23/2005	3	20.12	206.8	254	7.24	67.5	6.15	1016		73		
WAP-6	8/23/2005	4	19.14	207.5	252	7.12	69.0	6.37	1019		73		
WAP-7	3/15/2005	0.67	8.25	327	291	7.82	107.0	12.64	950			cloudy	light
WAP-7	5/5/2005	0.779	14.93	295.9	216	7.90	117.4	11.85	1000		70 F		
WAP-7	8/23/2005	0.377	26.55	243.1	217	7.33	76.1	6.4	930		64	Partly Cloudy	Light

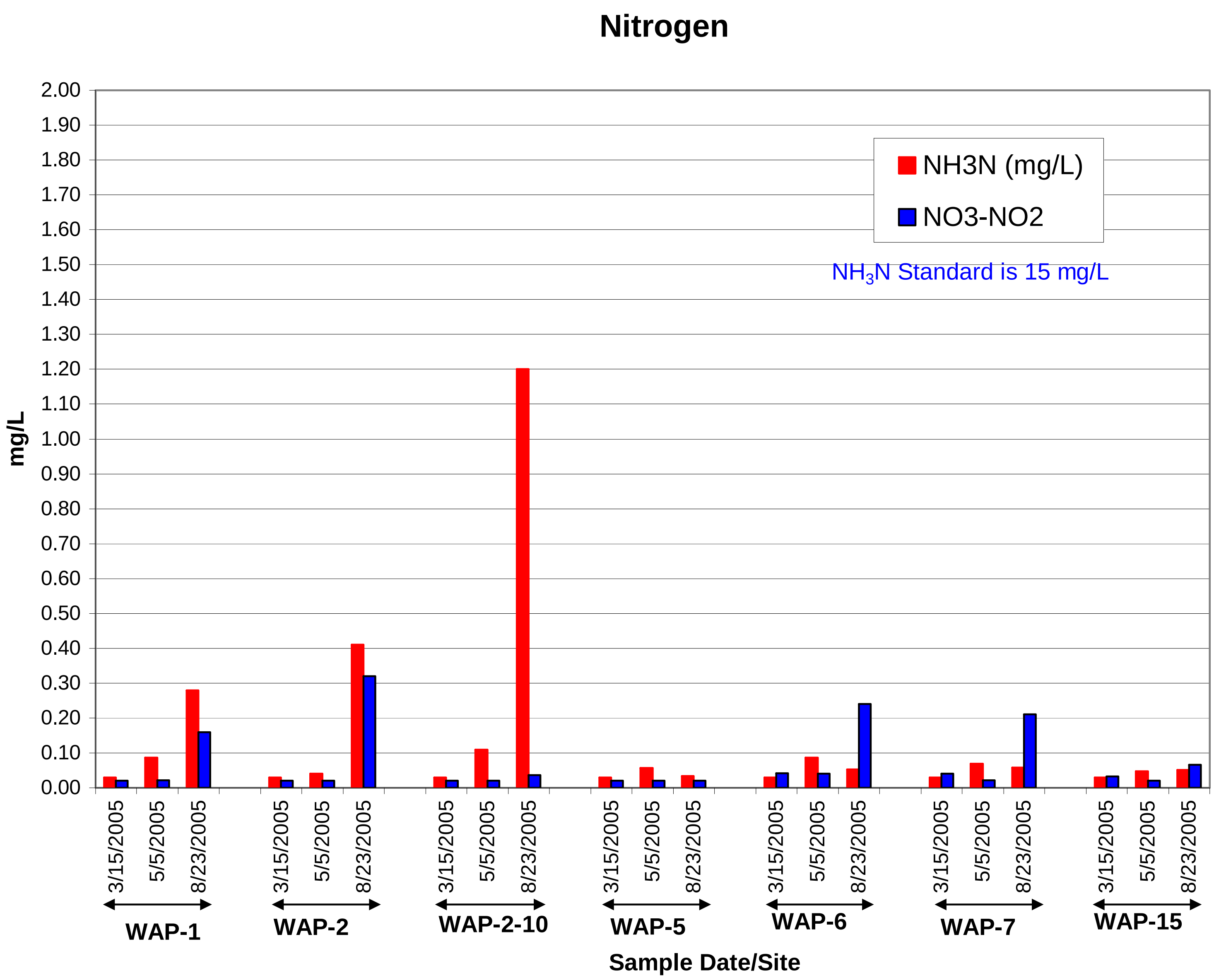
APPENDIX B

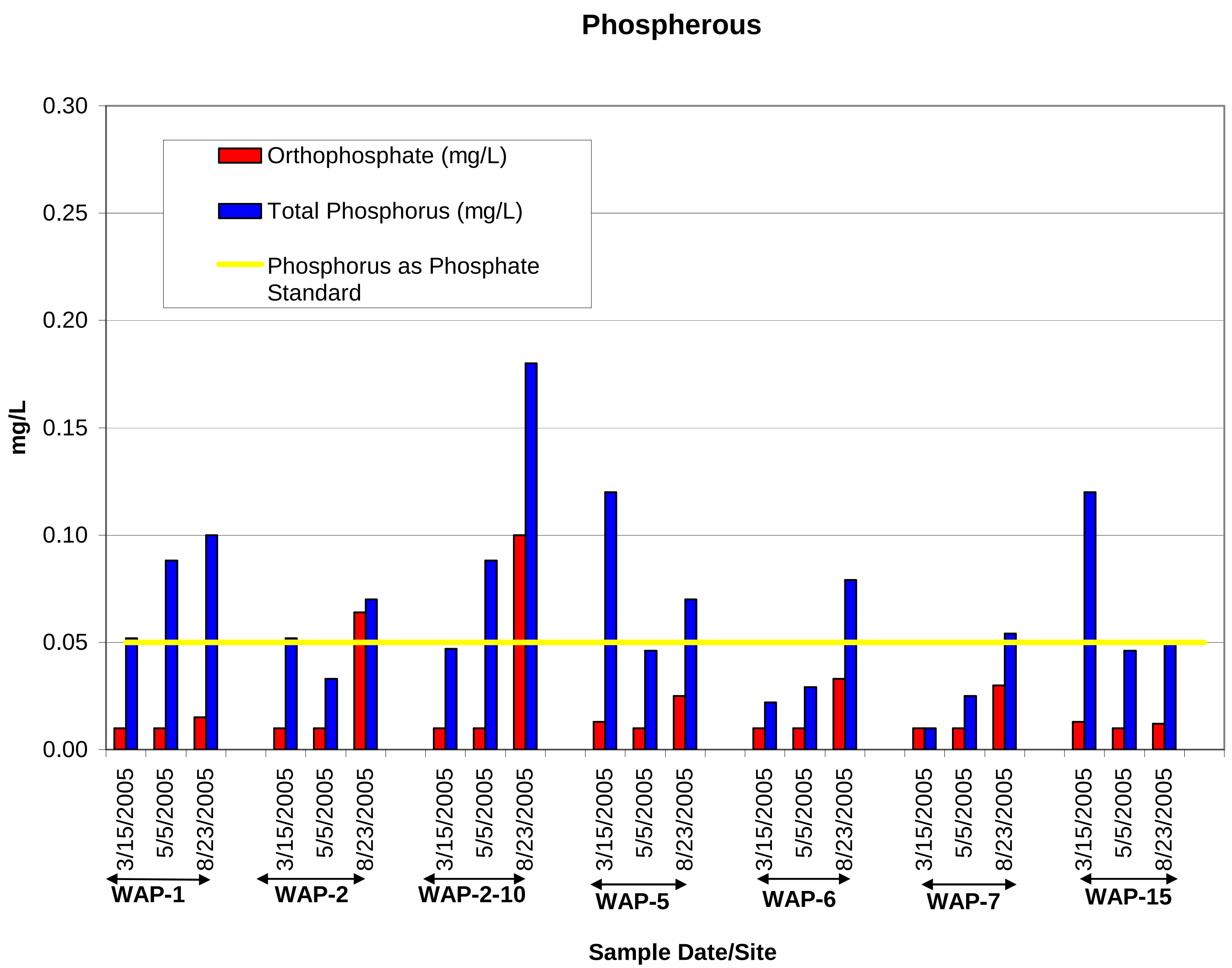
LAB DATA
GRAPHS

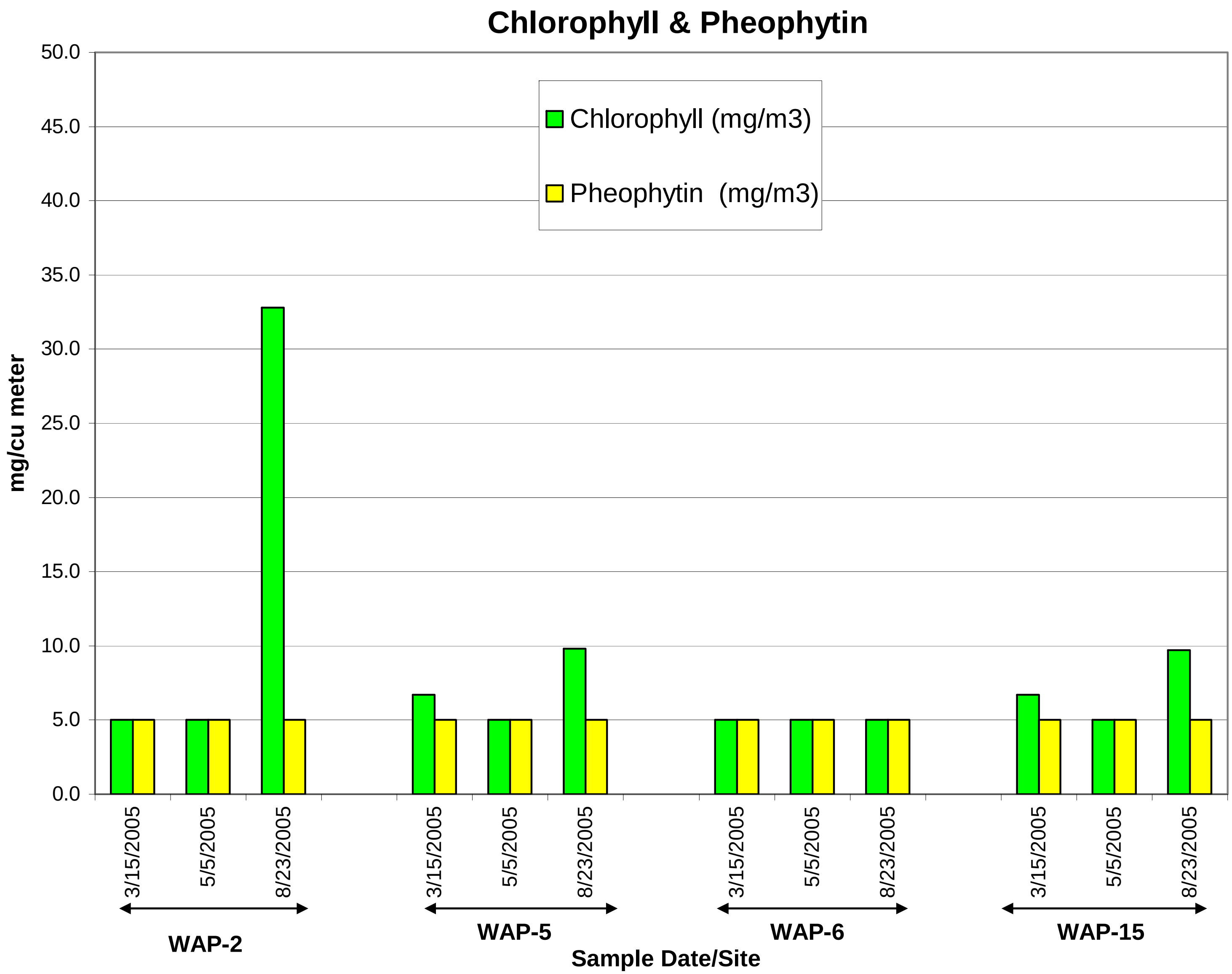


Marina
Fecal Coliform Colonies
Standard is 200 colonies/100ml
colonies/100ml
45
40
35
30
25
20
15
10
5
0
5/5/2005
8/23/2005
HL Mar
CL Mar
LC Mar
Sun Mar
Bar Mar
Sample Date/Site

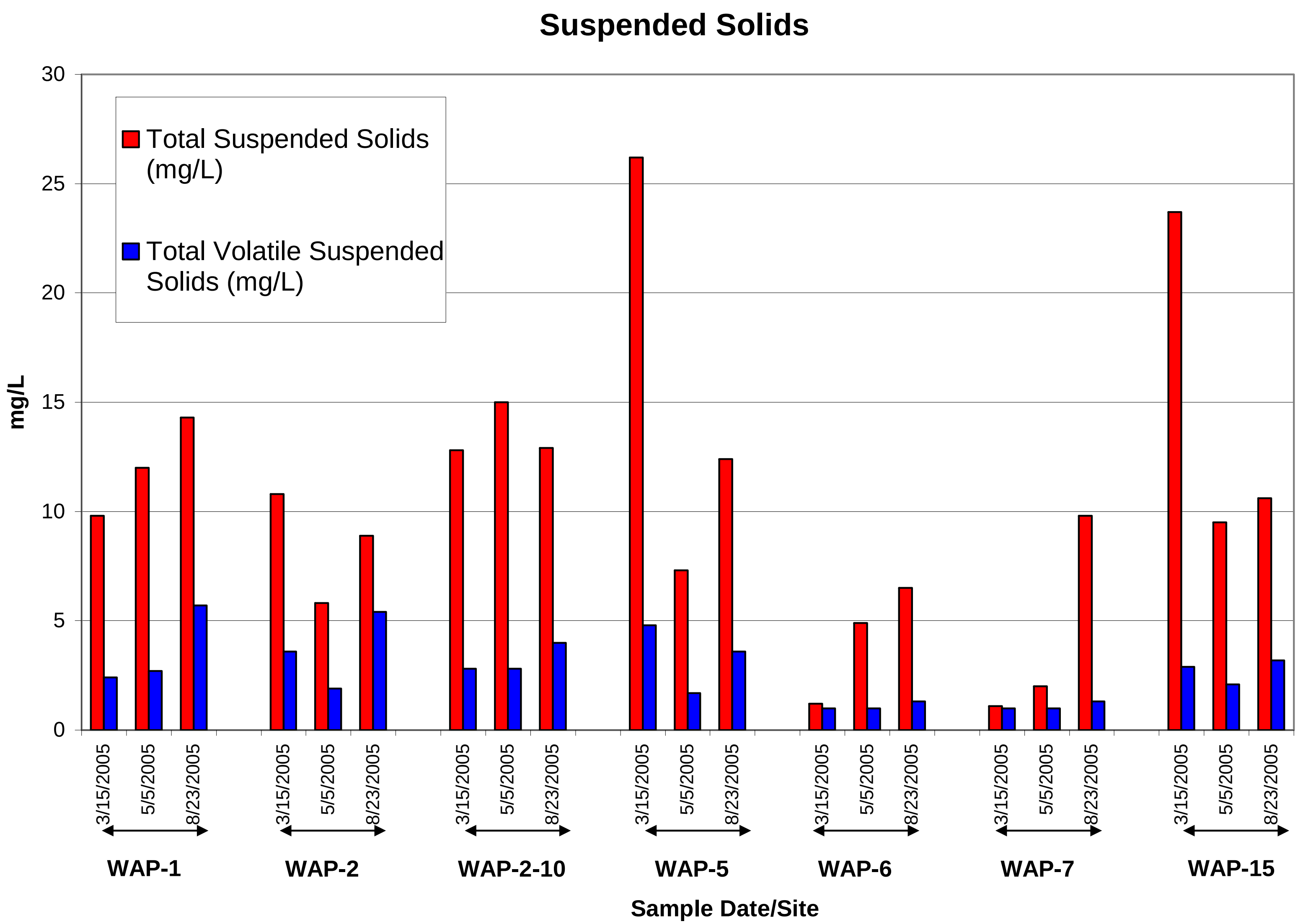

Metals
Total Iron
Total Manganese
mg/L
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Iron Standard
Manganese Standard
3/15/2005
5/5/2005
8/23/2005
3/15/2005
5/5/2005
8/23/2005
WAP-1
WAP-2-10
Sample Date/Site

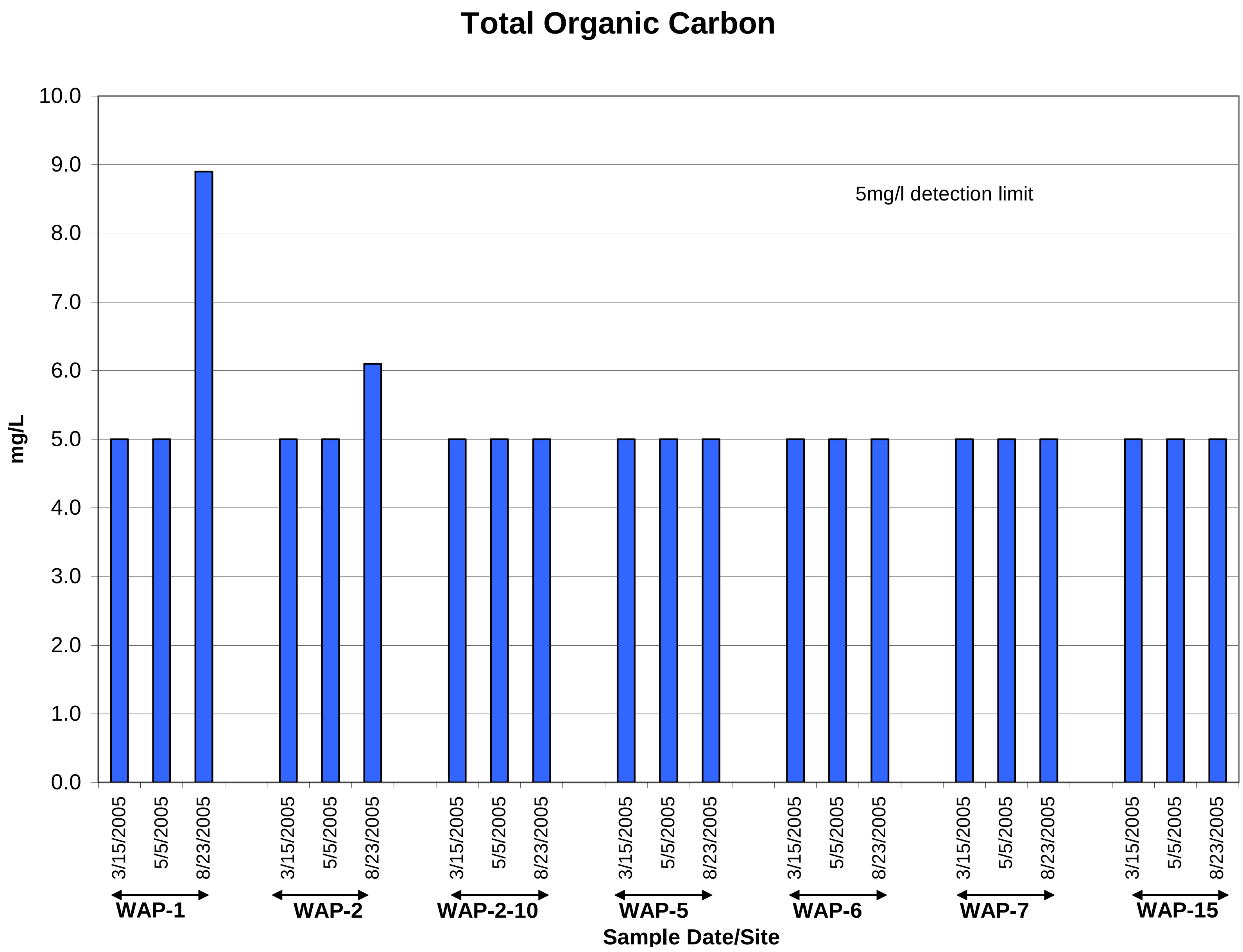

Nitrogen
mg/L
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
NH3N (mg/L)
NO3-NO2
NH$_3$N Standard is 15 mg/L
3/15/2005
5/5/2005
8/23/2005
WAP-1
WAP-2
WAP-2-10
WAP-5
WAP-6
WAP-7
WAP-15
Sample Date/Site


Phospherous
0.30
0.25
0.20
0.15
0.10
0.05
0.00
mg/L
Orthophosphate (mg/L)
Total Phosphorus (mg/L)
Phosphorus as Phosphate Standard
3/15/2005
5/5/2005
8/23/2005
WAP-1
WAP-2
WAP-2-10
WAP-5
WAP-6
WAP-7
WAP-15
Sample Date/Site



Chlorophyll & Pheophytin
Chlorophyll (mg/m3)
Pheophytin (mg/m3)
mg/cu meter
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
3/15/2005
5/5/2005
8/23/2005
3/15/2005
5/5/2005
8/23/2005
3/15/2005
5/5/2005
8/23/2005
3/15/2005
5/5/2005
8/23/2005
WAP-2
WAP-5
WAP-6
WAP-15
Sample Date/Site

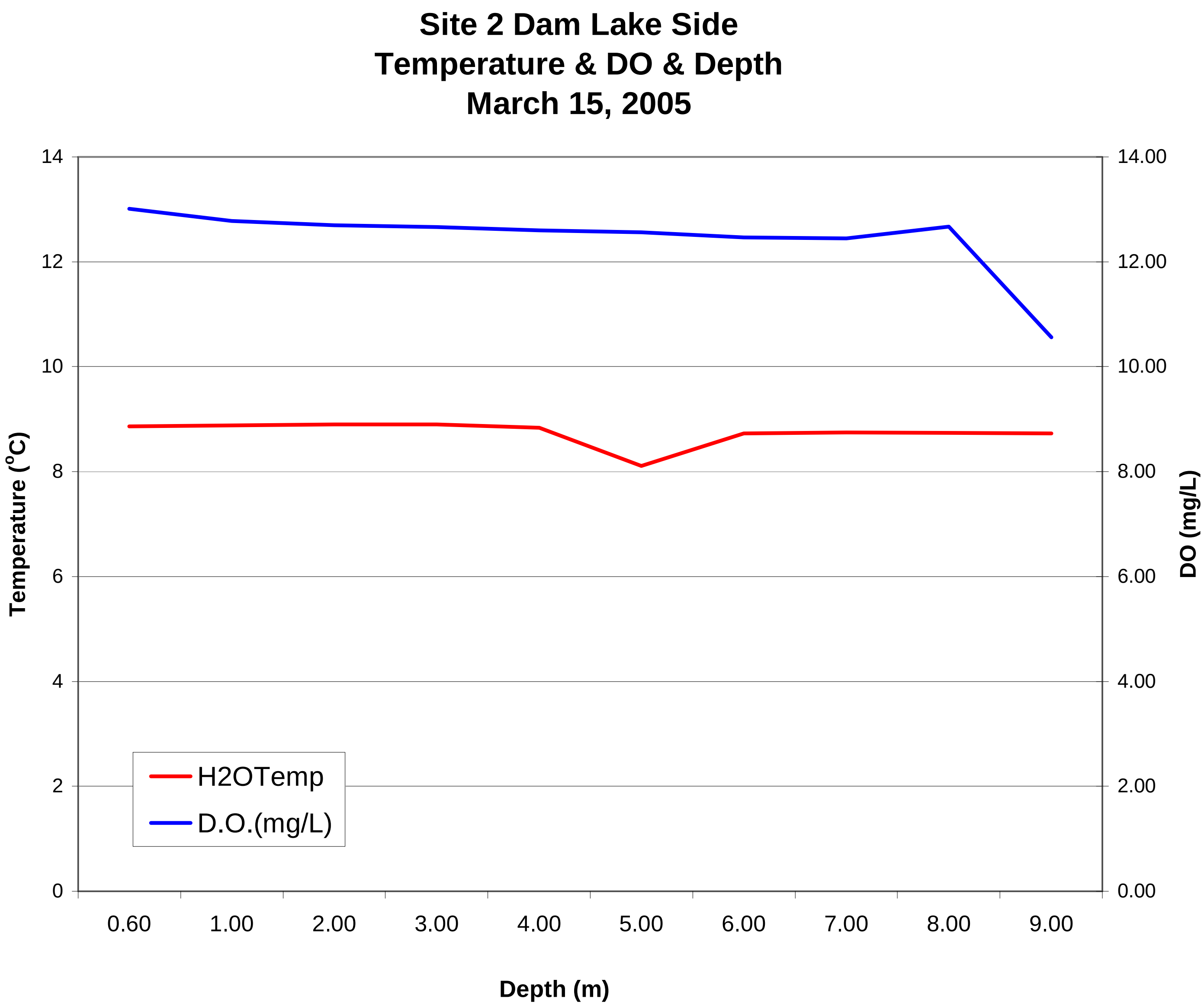

Suspended Solids
30
25
20
15
10
5
0
mg/L
Total Suspended Solids (mg/L)
Total Volatile Suspended Solids (mg/L)
3/15/2005
5/5/2005
8/23/2005
WAP-1
WAP-2
WAP-2-10
WAP-5
WAP-6
WAP-7
WAP-15
Sample Date/Site


Total Organic Carbon
mg/L
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
5mg/l detection limit
3/15/2005
5/5/2005
8/23/2005
WAP-1
WAP-2
WAP-2-10
WAP-5
WAP-6
WAP-7
WAP-15
Sample Date/Site

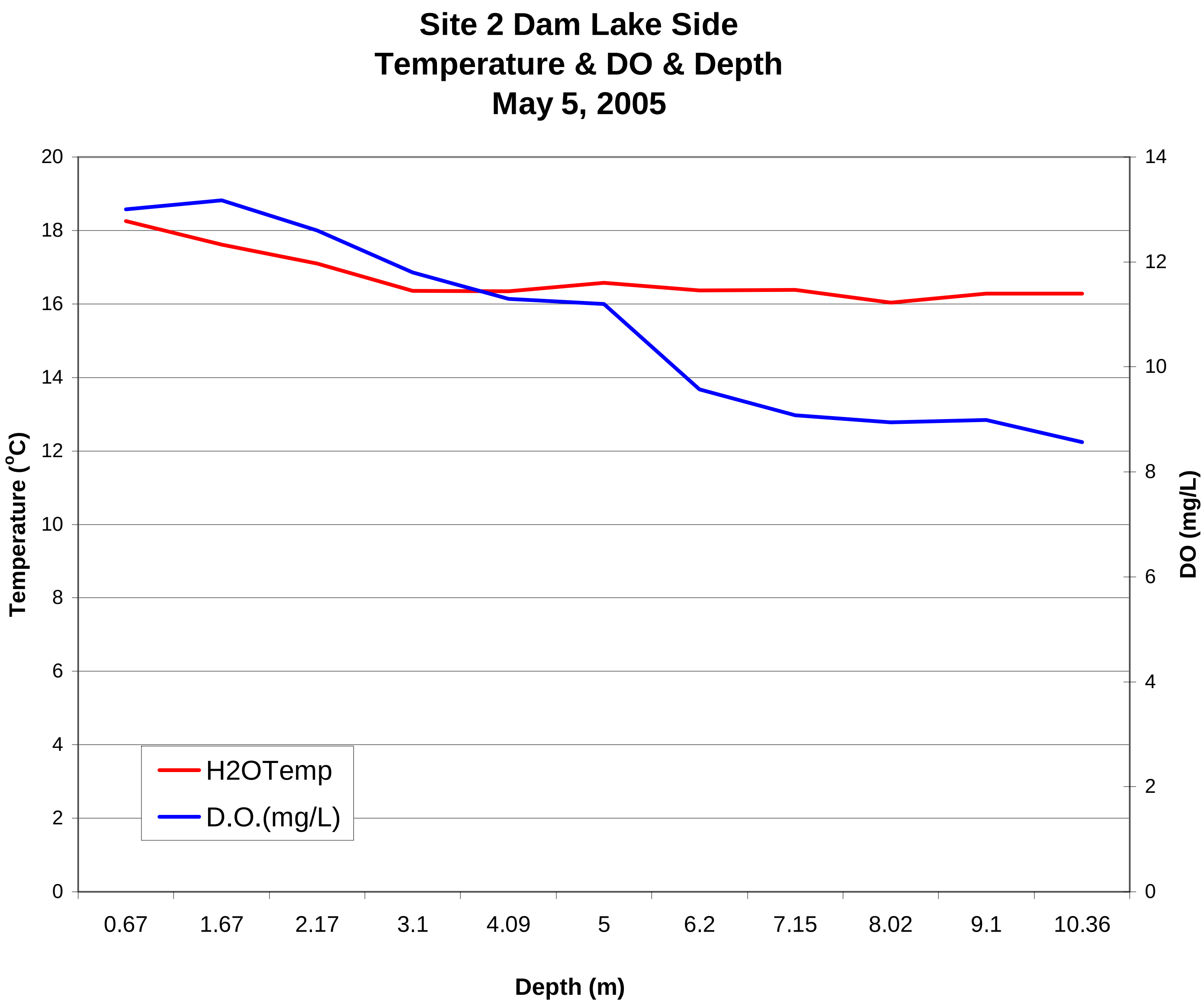
APPENDIX C

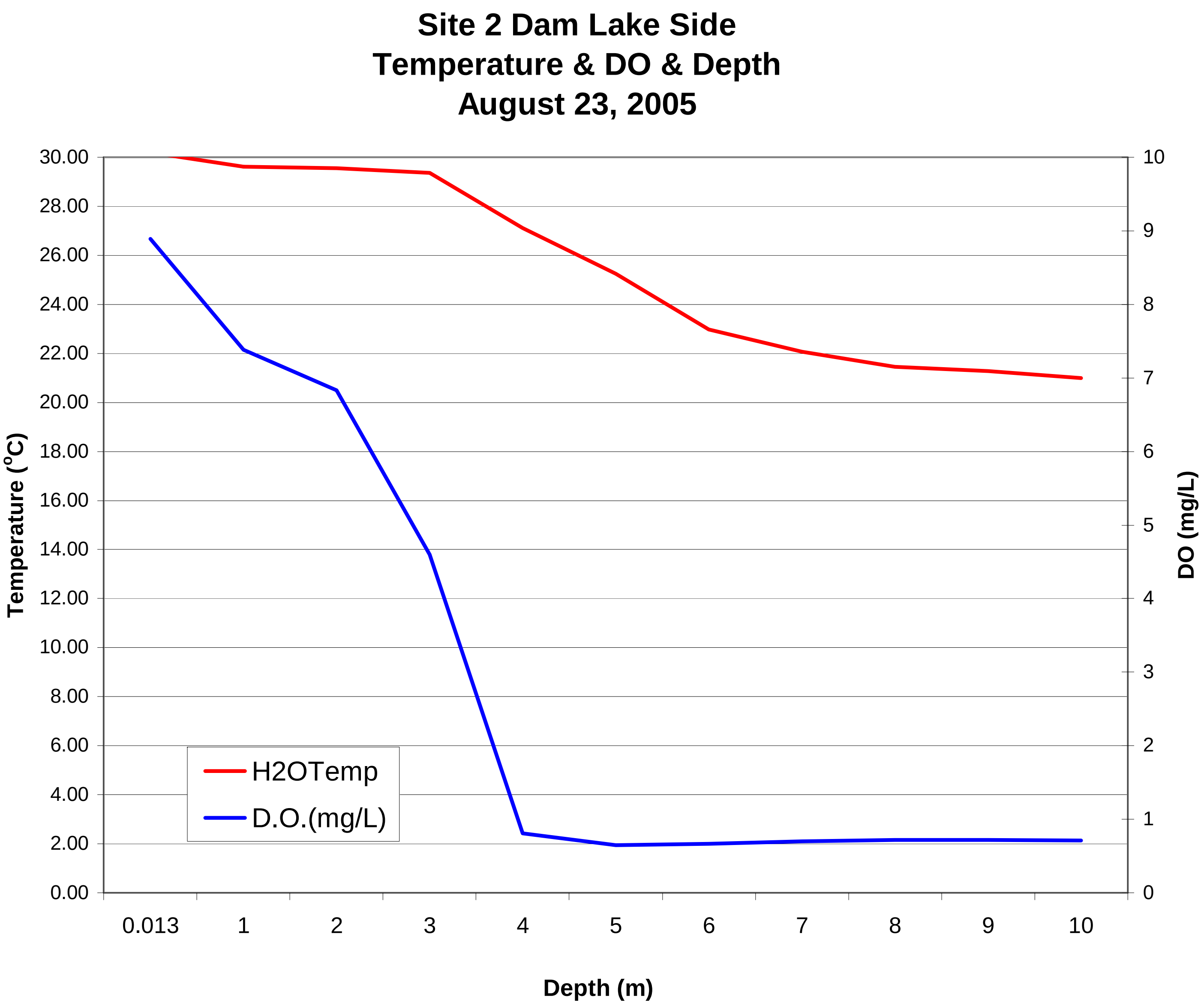
FIELD DATA GRAPHS


Site 1 Spillway
Temperature & DO
H2OTemp
D.O.(mg/L)
Temperature (°C)
DO (mg/L)
Sample Date
3/15/2005
5/5/2005
8/23/2005
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00



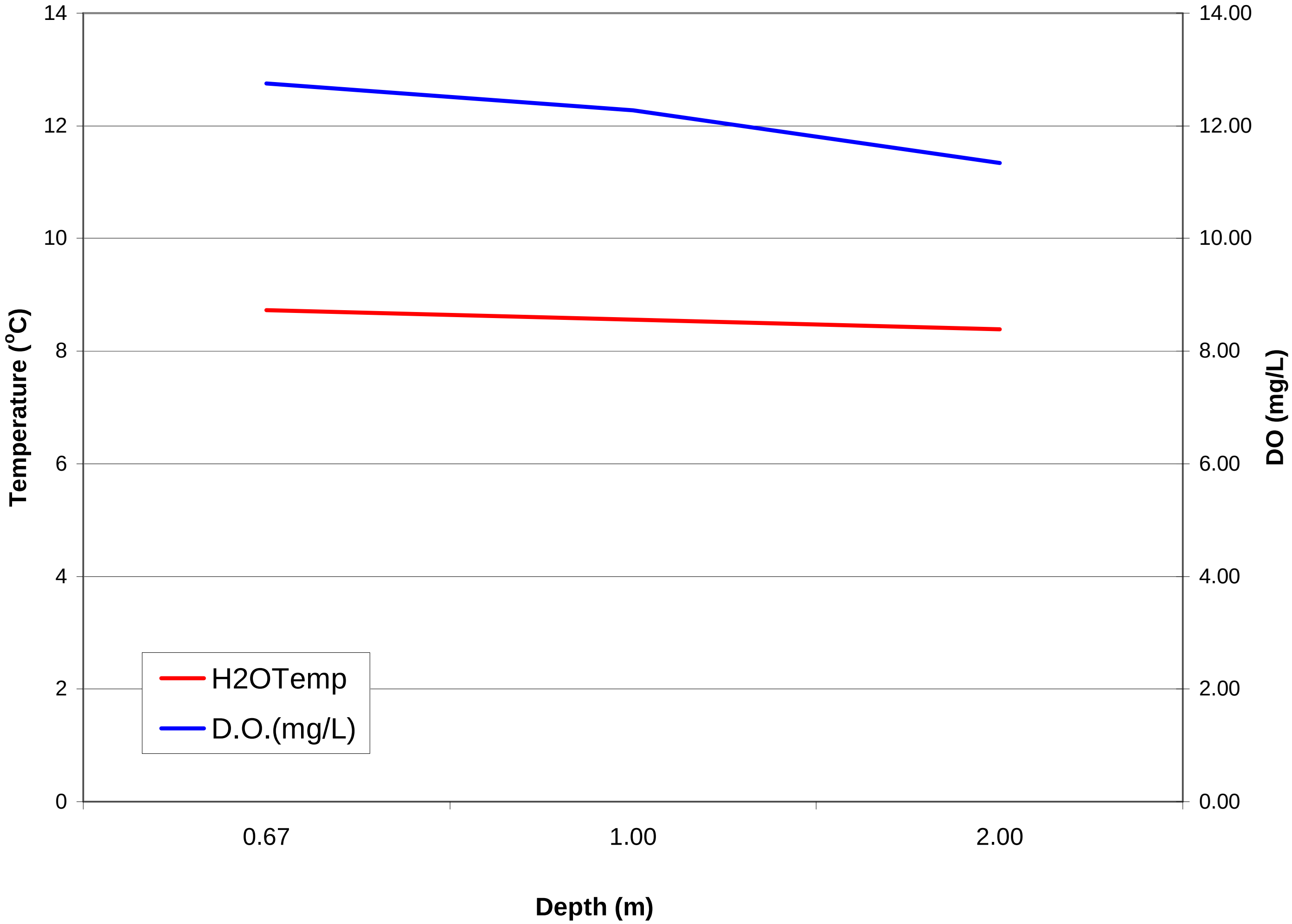
Site 2 Dam Lake Side
Temperature & DO & Depth
March 15, 2005
Temperature (°C)
DO (mg/L)
Depth (m)
0
2
4
6
8
10
12
14
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
0.60
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
H2OTemp
D.O.(mg/L)

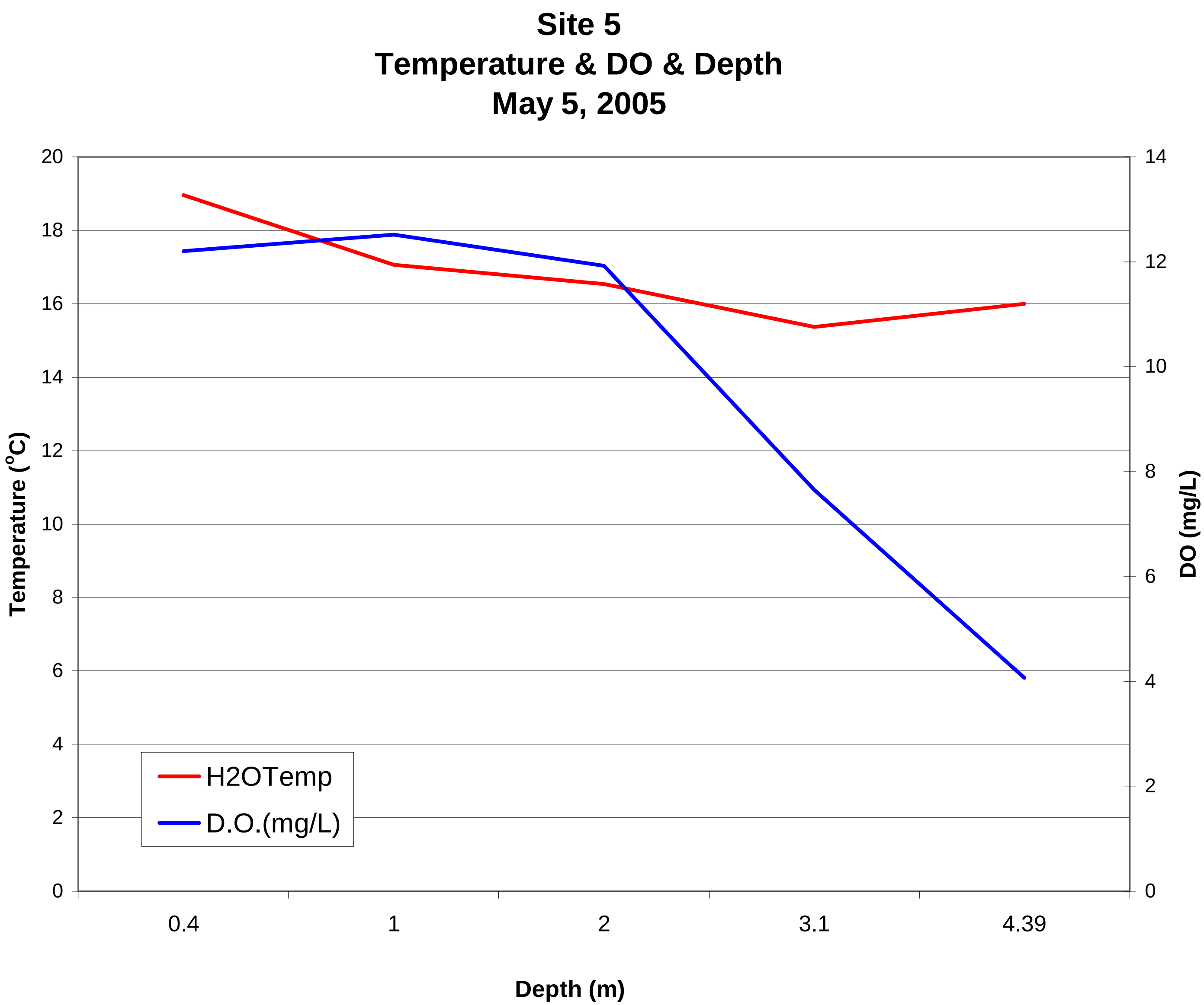

Site 2 Dam Lake Side
Temperature & DO & Depth
May 5, 2005
Temperature (°C)
DO (mg/L)
Depth (m)
0
2
4
6
8
10
12
14
16
18
20
0
2
4
6
8
10
12
14
0.67
1.67
2.17
3.1
4.09
5
6.2
7.15
8.02
9.1
10.36
H2OTemp
D.O.(mg/L)

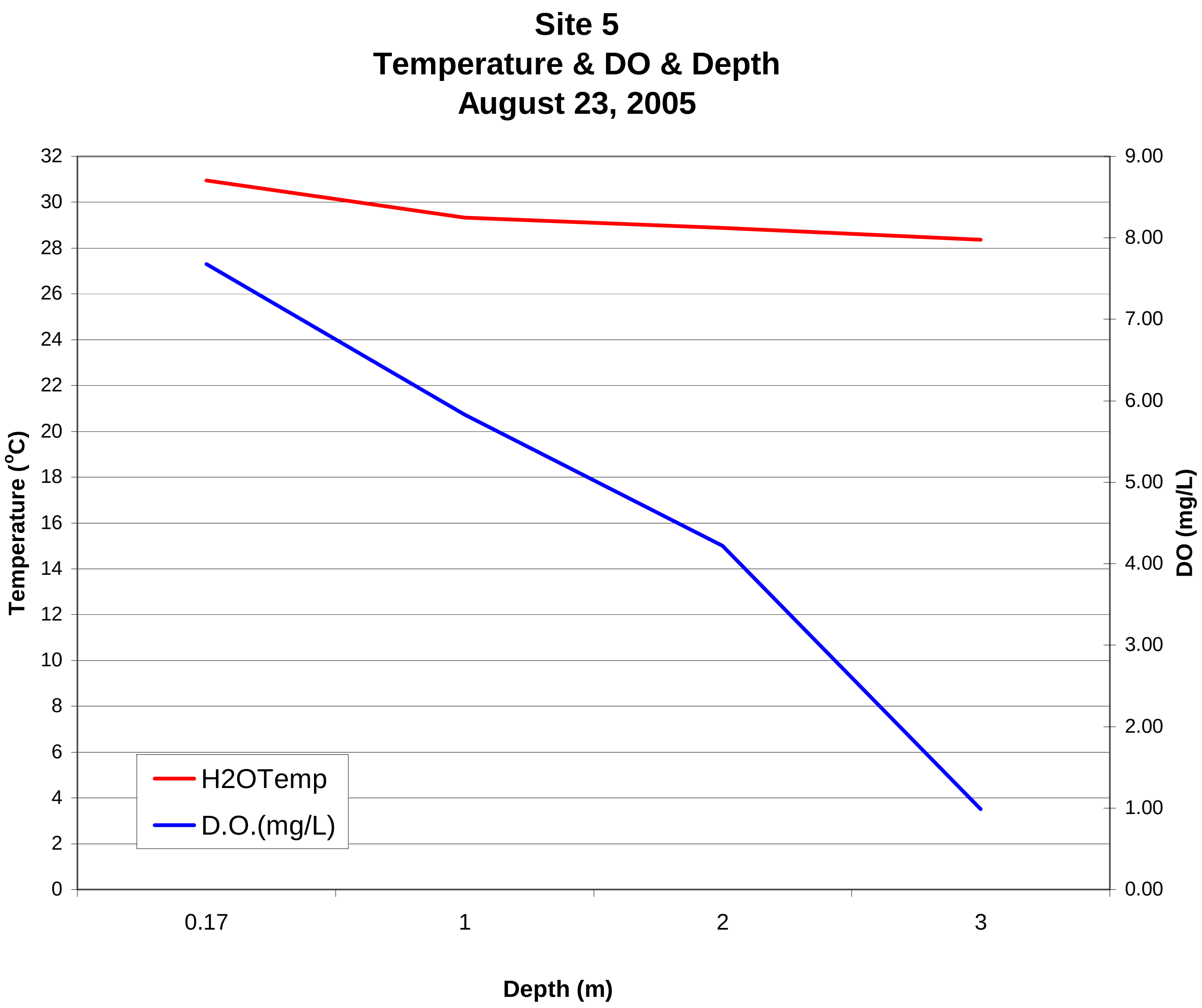


Site 2 Dam Lake Side
Temperature & DO & Depth
August 23, 2005
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Temperature (°C)
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
0.013
1
2
3
4
5
6
7
8
9
10
Depth (m)
H2OTemp
D.O.(mg/L)

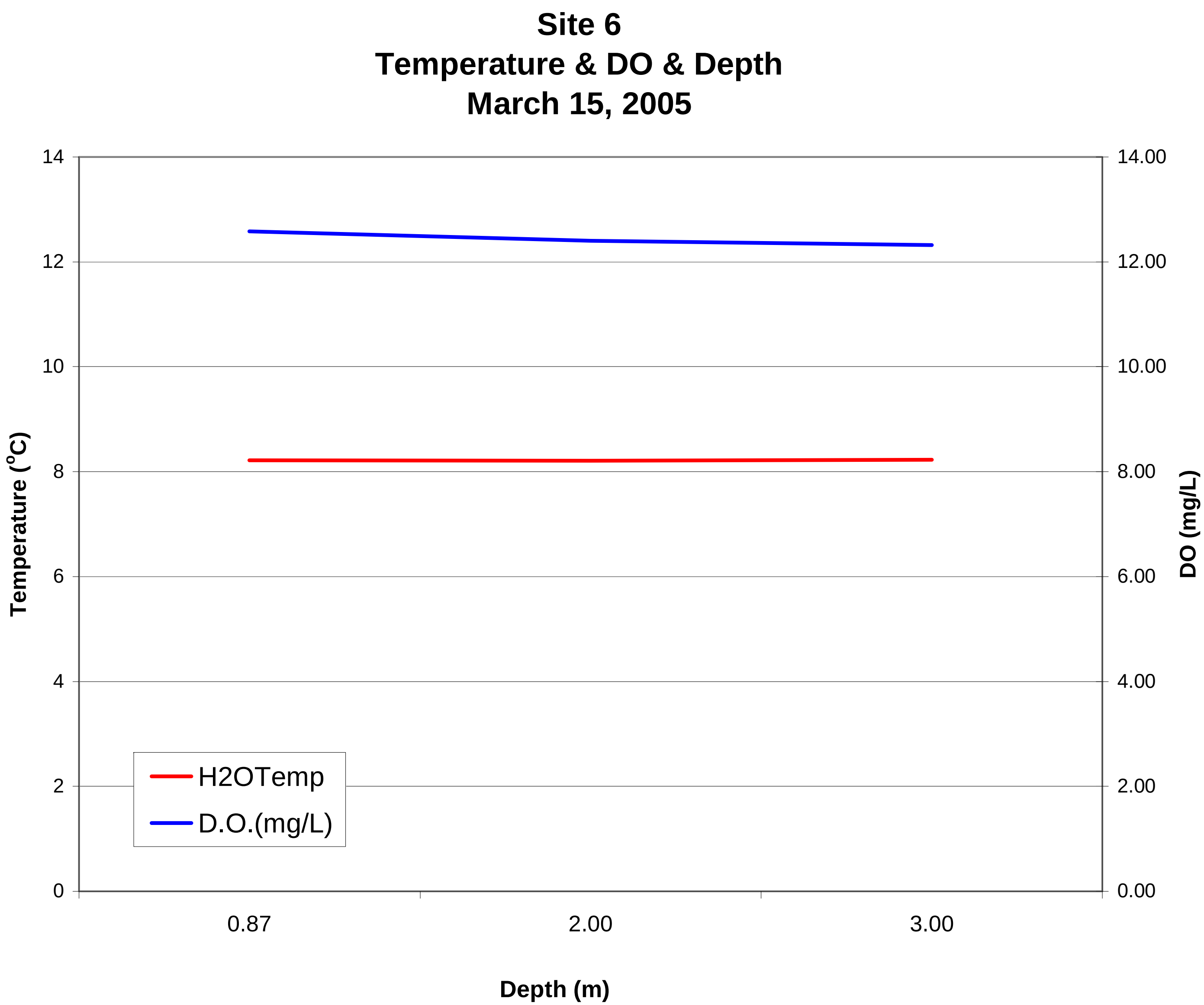
Site 5
Temperature & DO & Depth
March 15, 2005

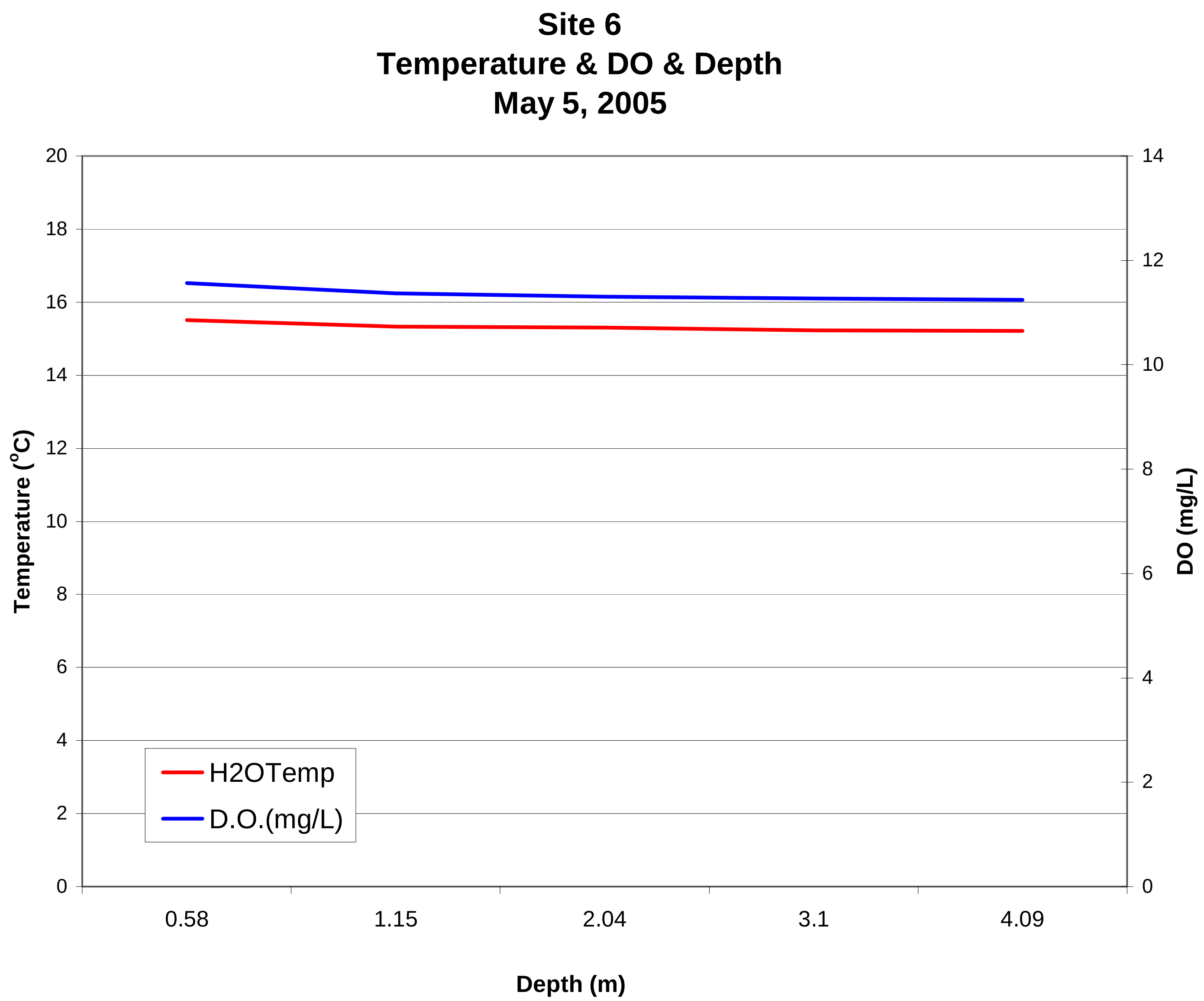


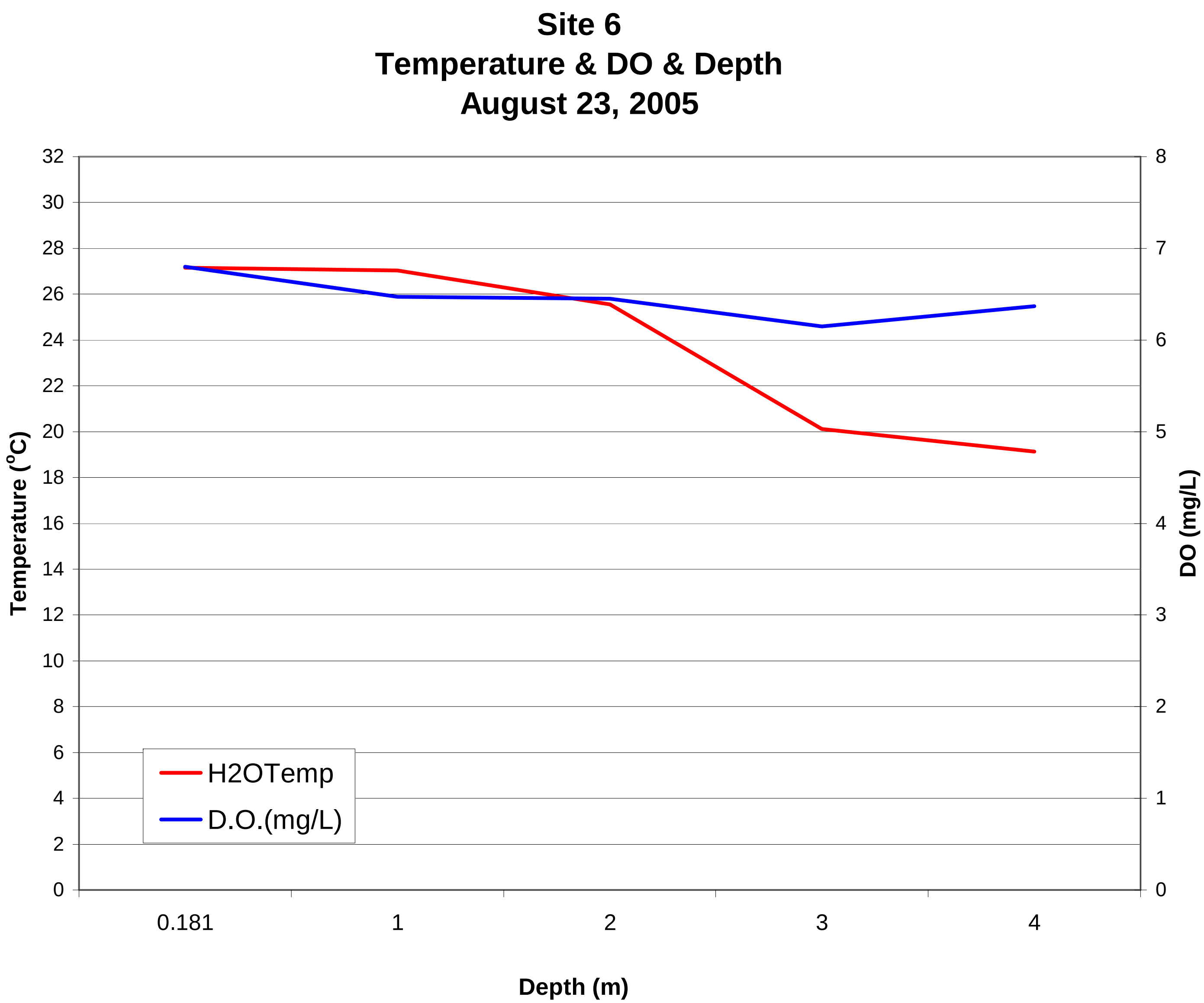

Site 5
Temperature & DO & Depth
May 5, 2005
20
18
16
14
12
10
8
6
4
2
0
Temperature (oC)
14
12
10
8
6
4
2
0
DO (mg/L)
H2OTemp
D.O.(mg/L)
0.4
1
2
3.1
4.39
Depth (m)

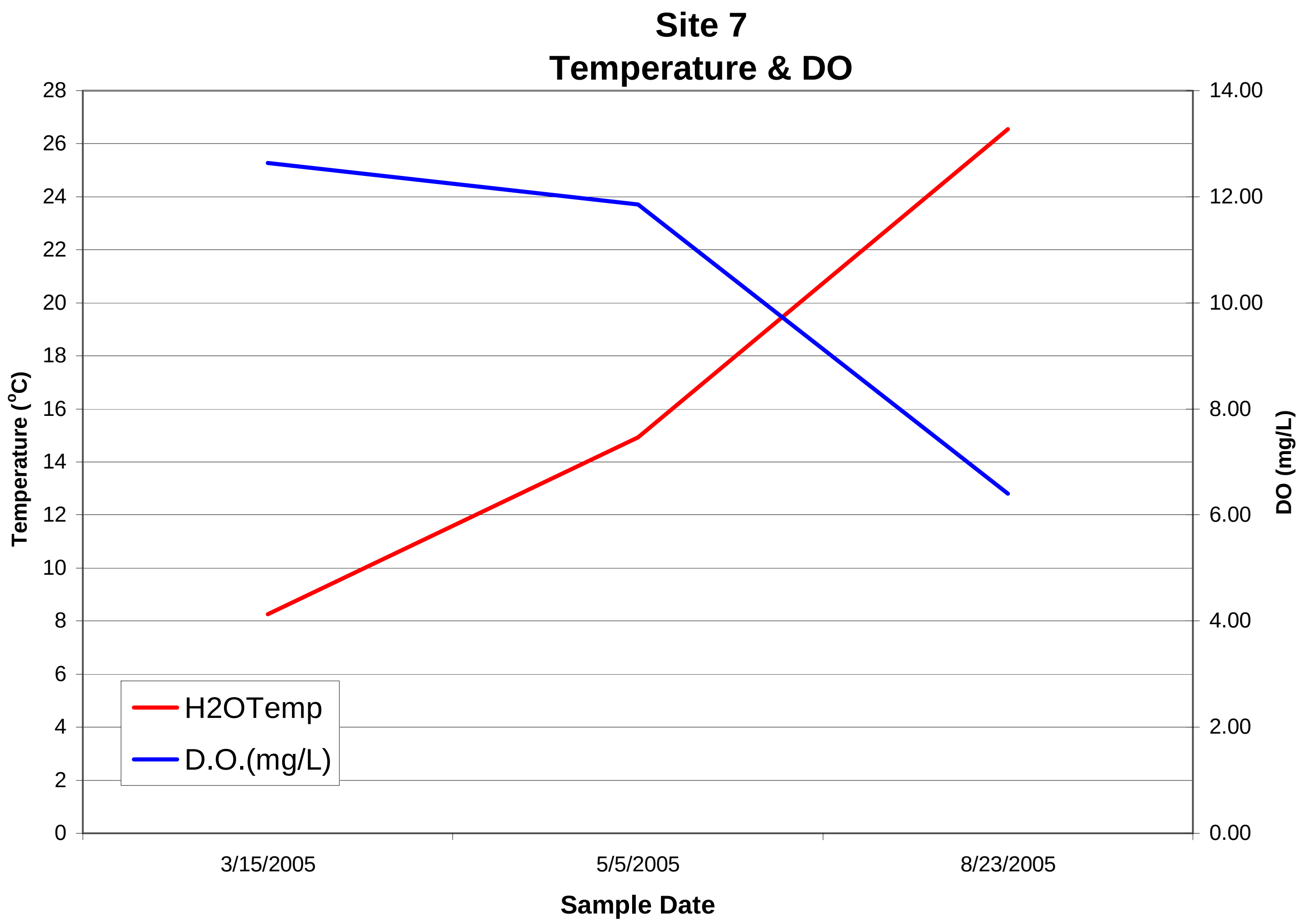


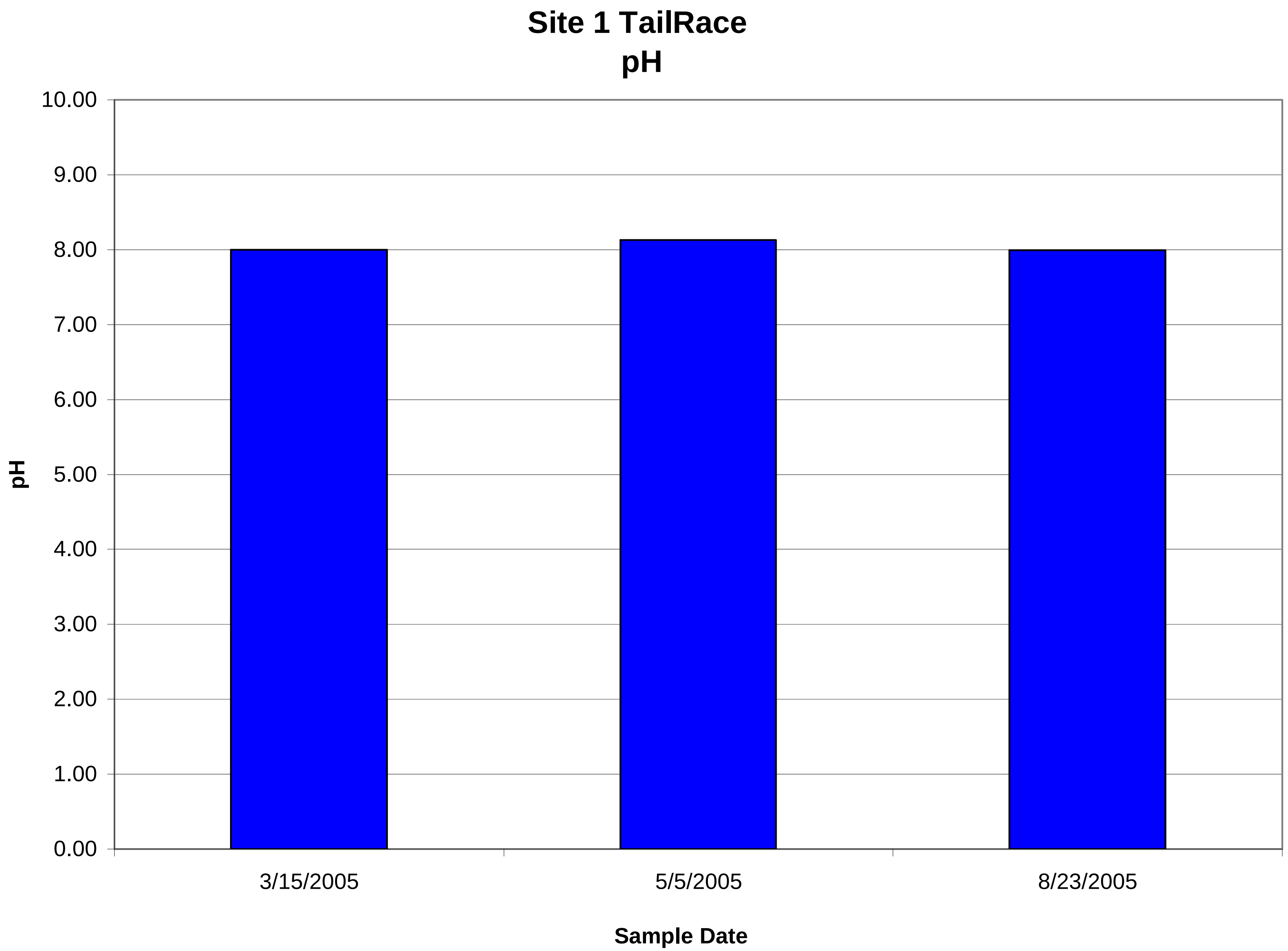
Site 5
Temperature & DO & Depth
August 23, 2005
Temperature (°C)
DO (mg/L)
Depth (m)
0.17
1
2
3
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
H2OTemp
D.O.(mg/L)

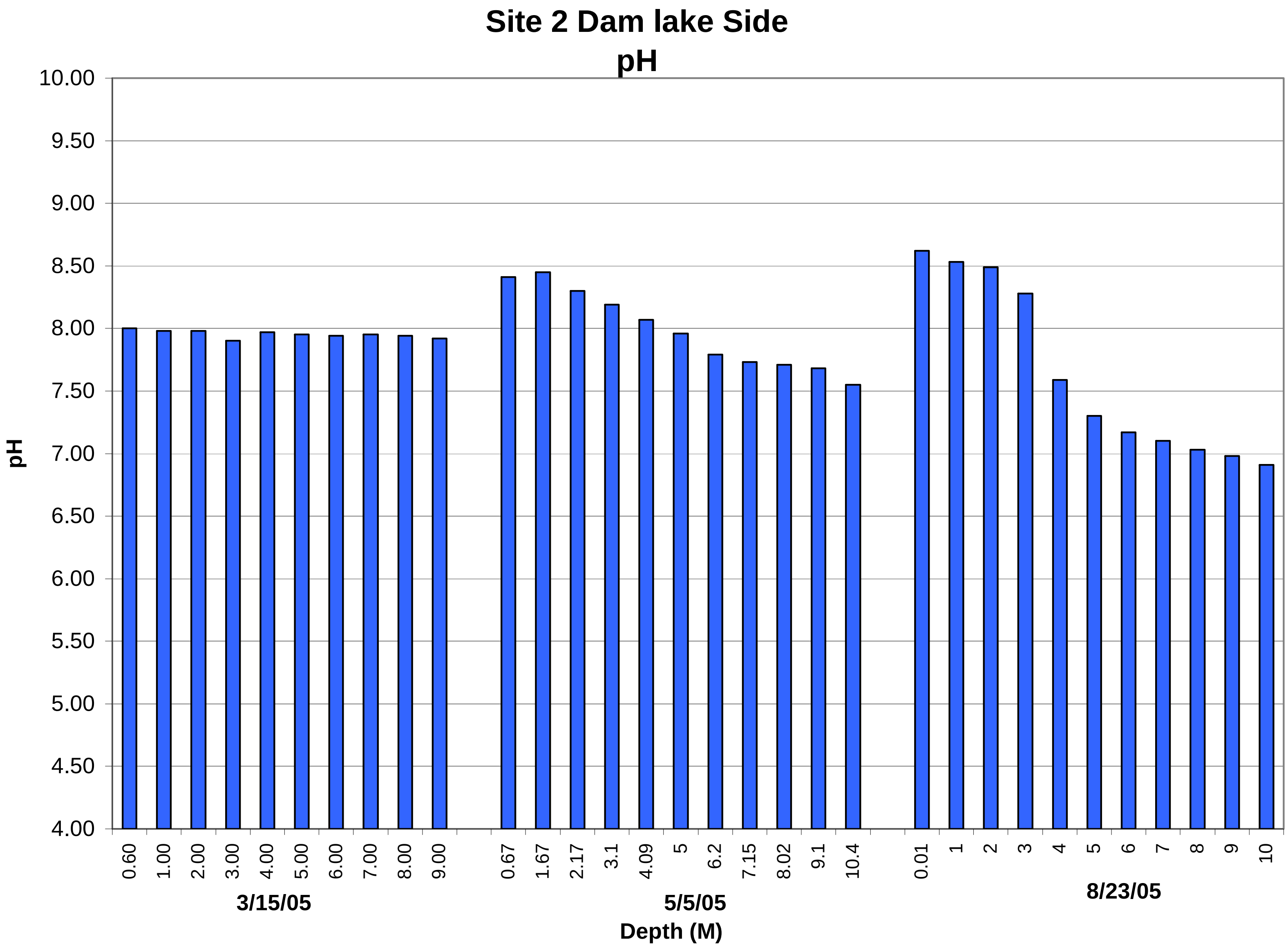

Site 6
Temperature & DO & Depth
March 15, 2005
Temperature (°C)
DO (mg/L)
Depth (m)
0.87
2.00
3.00
0
2
4
6
8
10
12
14
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
H2OTemp
D.O.(mg/L)

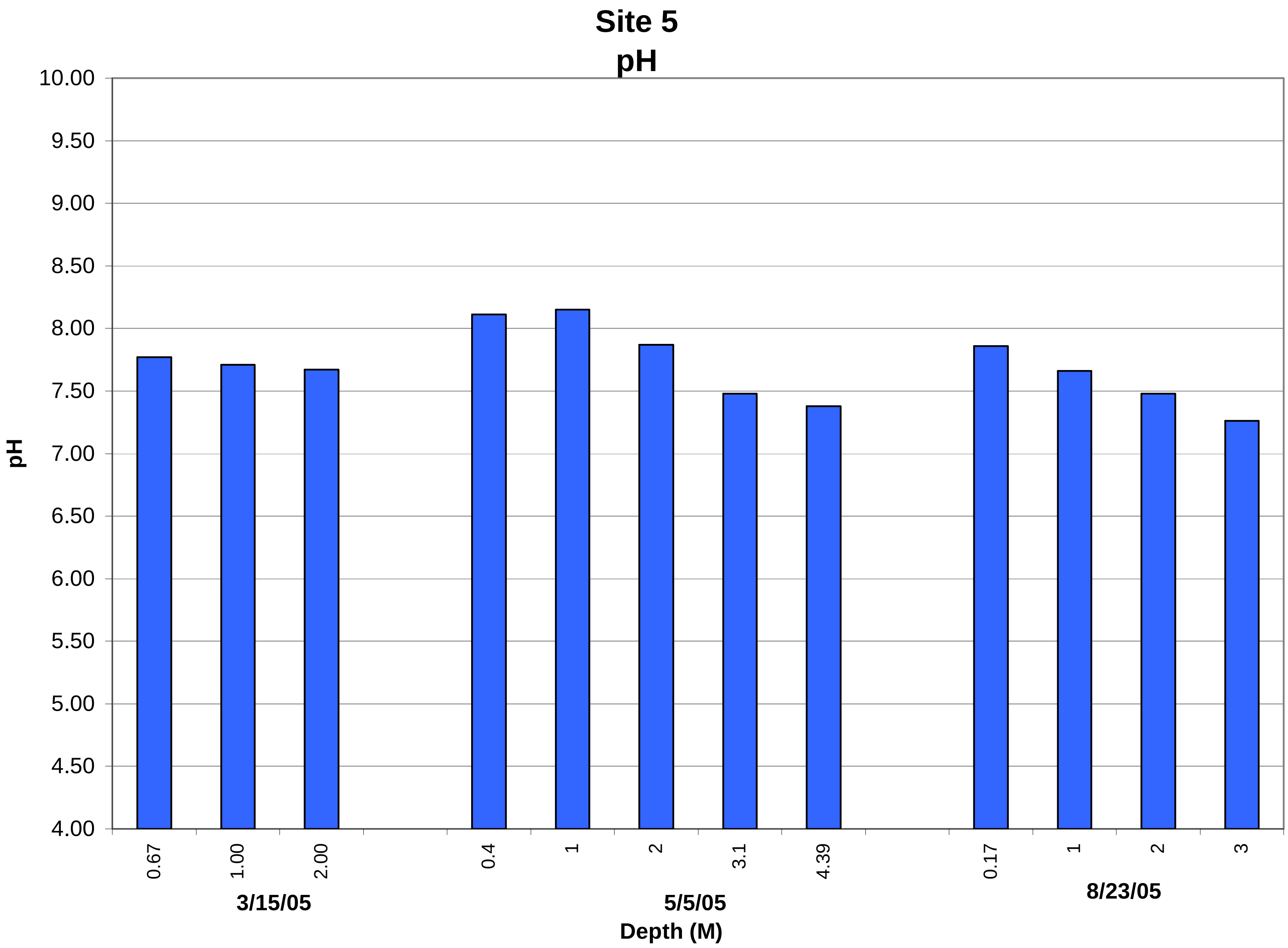

Site 6
Temperature & DO & Depth
May 5, 2005
Temperature (°C)
DO (mg/L)
Depth (m)
0.58
1.15
2.04
3.1
4.09
H2OTemp
D.O.(mg/L)

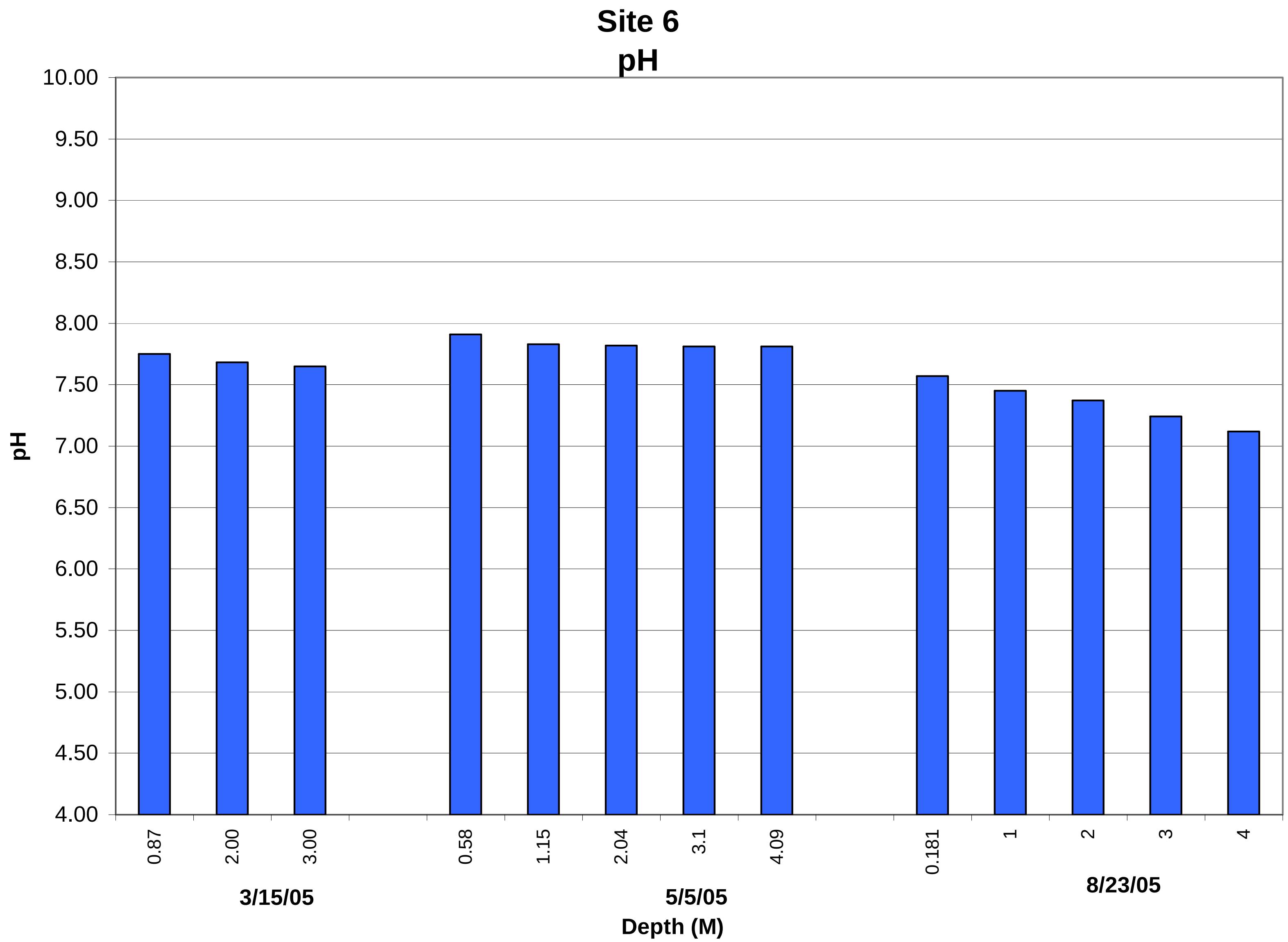

Site 6
Temperature & DO & Depth
August 23, 2005
Temperature (°C)
DO (mg/L)
Depth (m)
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
8
7
6
5
4
3
2
1
0
0.181
1
2
3
4
H2OTemp
D.O.(mg/L)

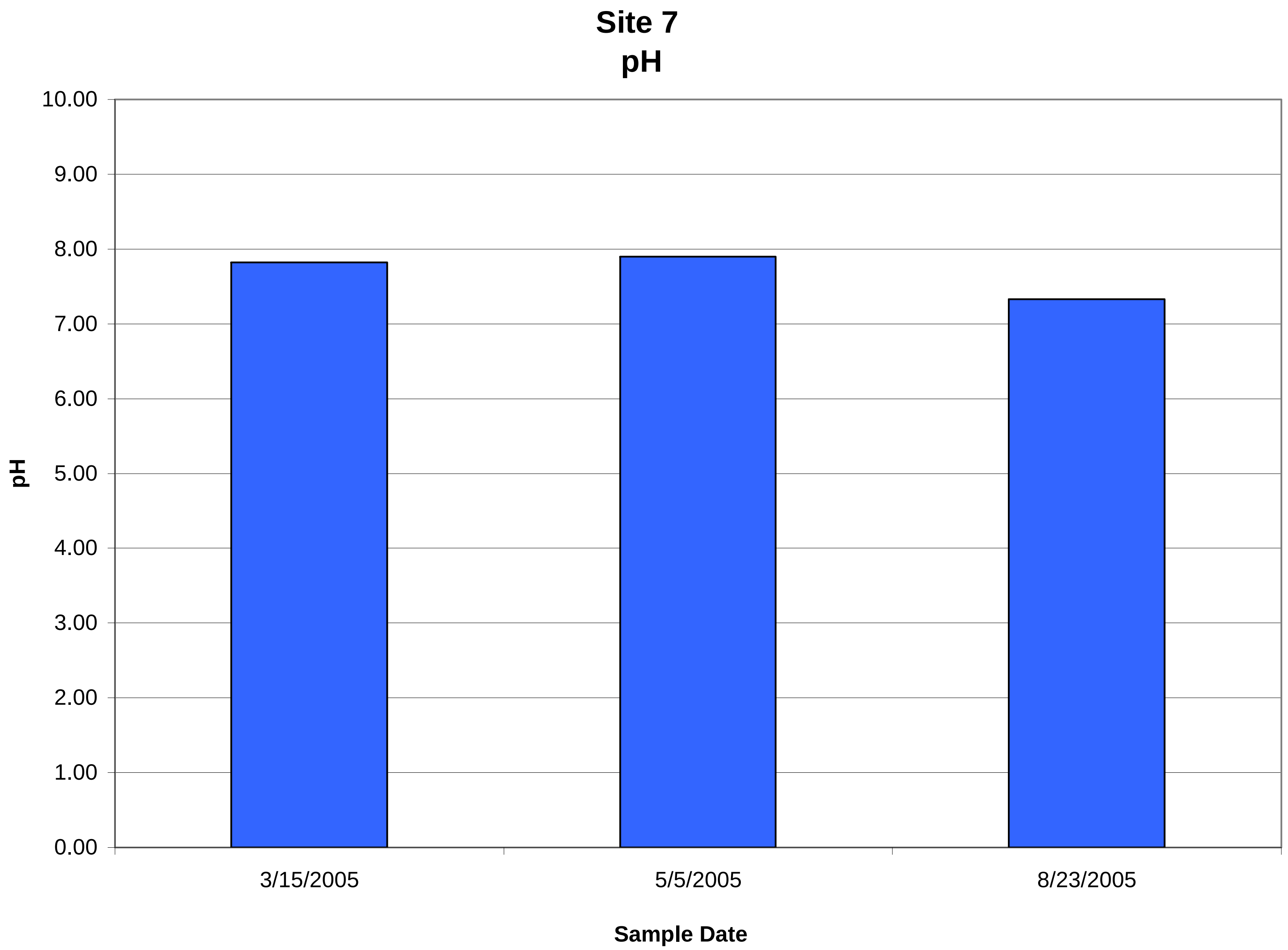

Site 7
Temperature & DO
Temperature (°C)
DO (mg/L)
Sample Date
3/15/2005
5/5/2005
8/23/2005
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
H2OTemp
D.O.(mg/L)

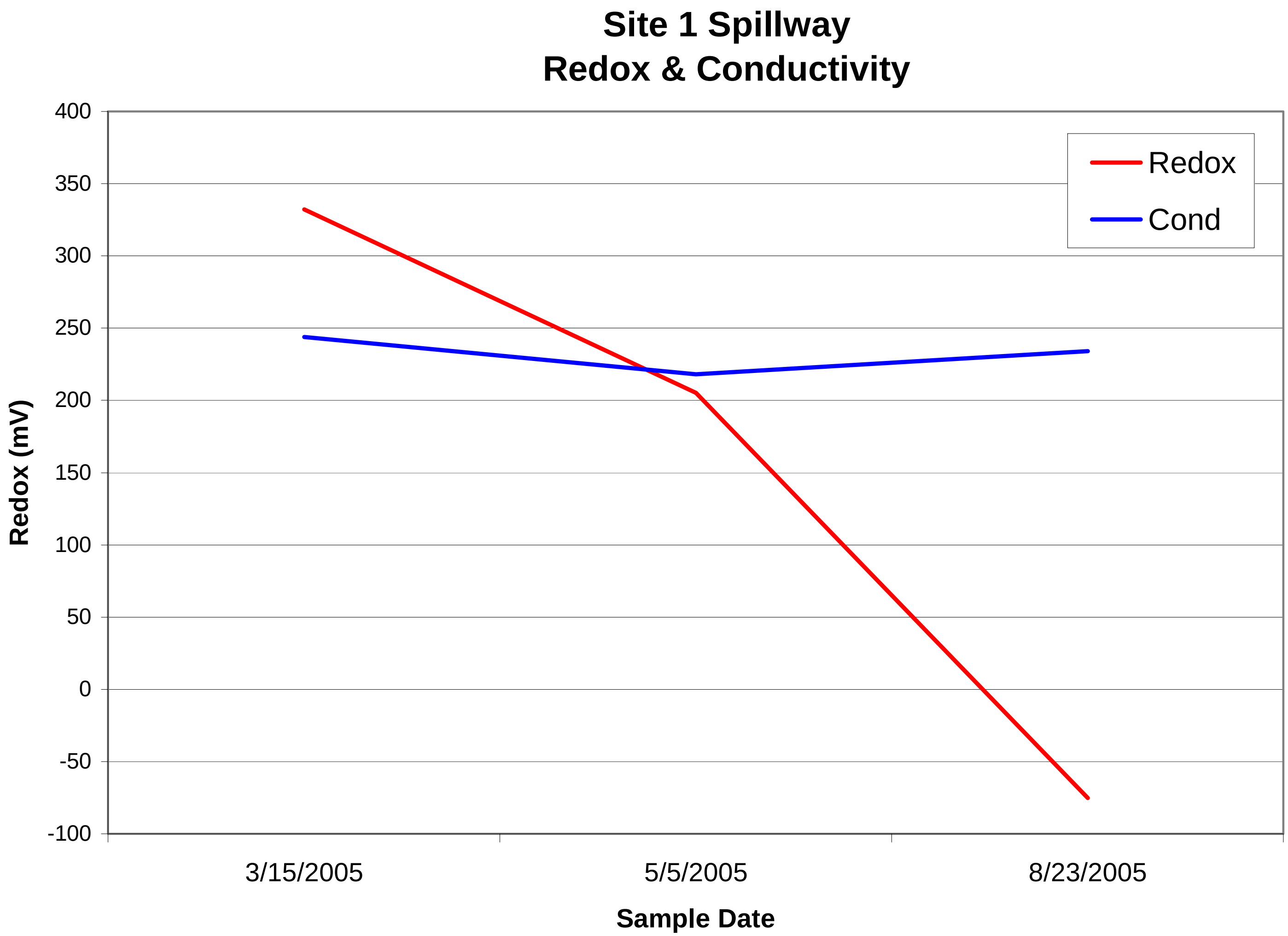

Site 1 TailRace
pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
pH
3/15/2005
5/5/2005
8/23/2005
Sample Date

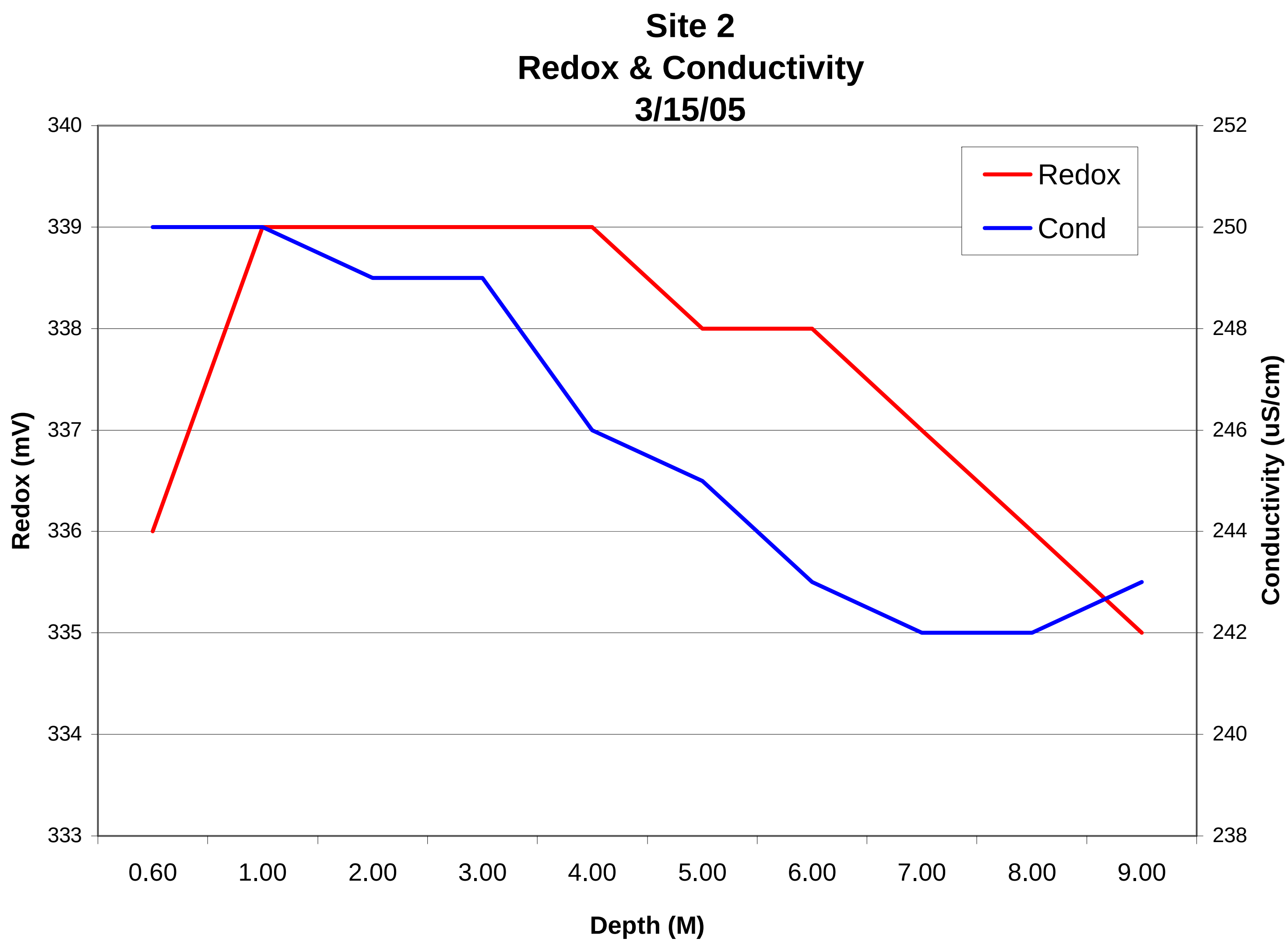

Site 2 Dam lake Side
pH
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
pH
0.60
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
0.67
1.67
2.17
3.1
4.09
5
6.2
7.15
8.02
9.1
10.4
0.01
1
2
3
4
5
6
7
8
9
10
3/15/05
5/5/05
8/23/05
Depth (M)

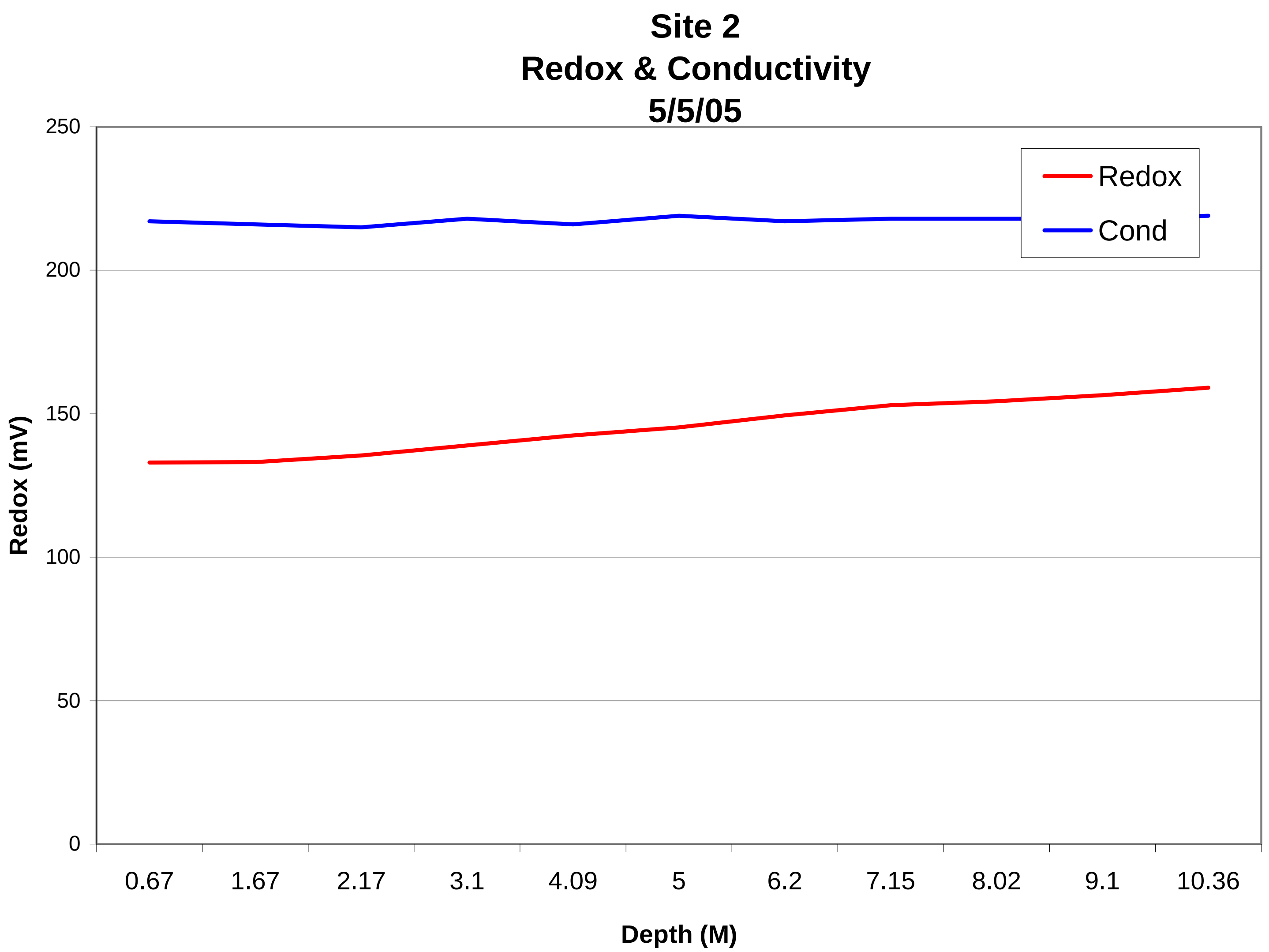

Site 5
pH
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
pH
0.67
1.00
2.00
0.4
1
2
3.1
4.39
0.17
1
2
3
3/15/05
5/5/05
8/23/05
Depth (M)

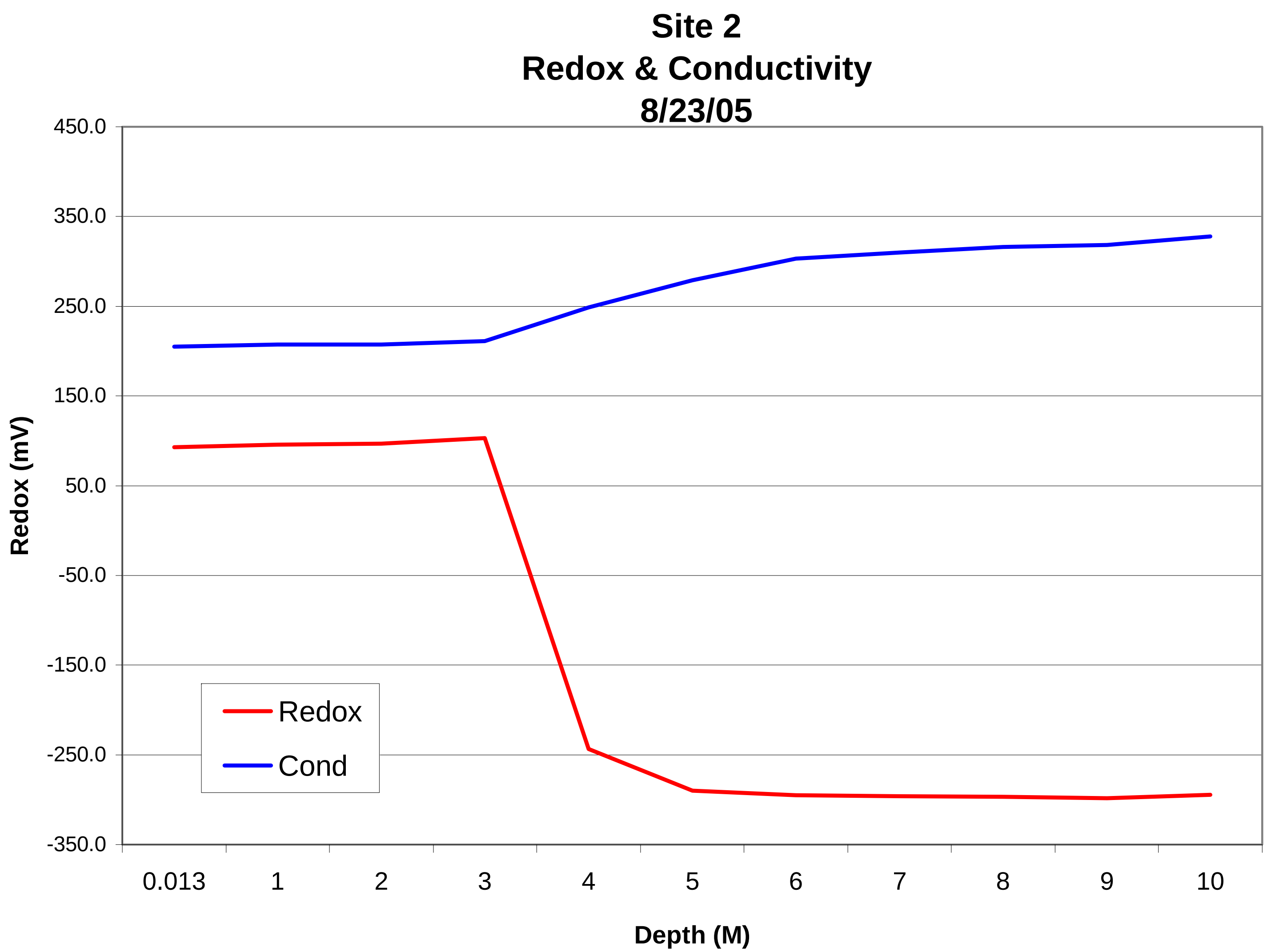

Site 6
pH
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
pH
0.87
2.00
3.00
0.58
1.15
2.04
3.1
4.09
0.181
1
2
3
4
3/15/05
5/5/05
8/23/05
Depth (M)

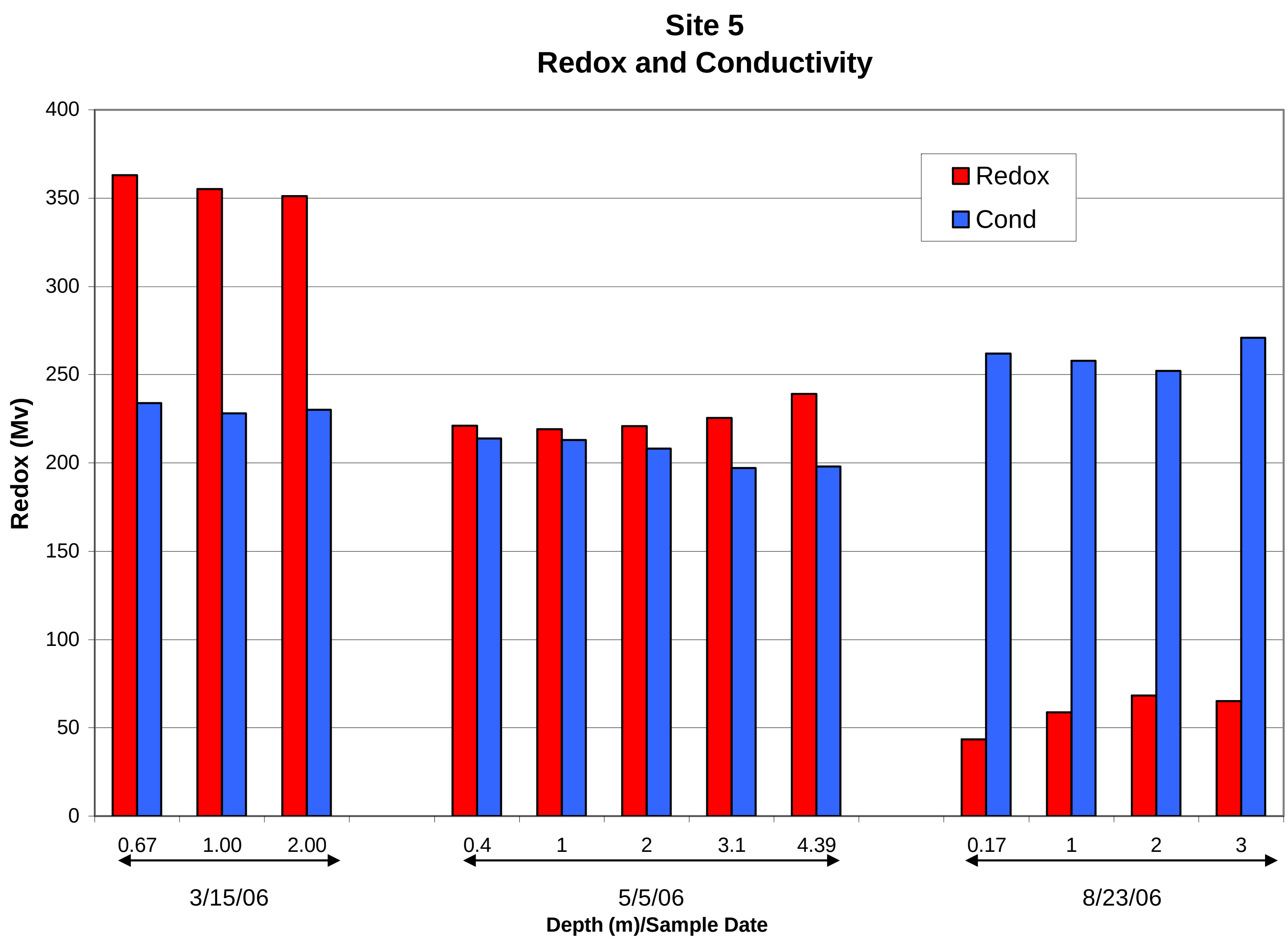

Site 7
pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
pH
3/15/2005
5/5/2005
8/23/2005
Sample Date


Site 1 Spillway
Redox & Conductivity
400
350
300
250
200
150
100
50
0
-50
-100
Redox (mV)
Redox
Cond
3/15/2005
5/5/2005
8/23/2005
Sample Date

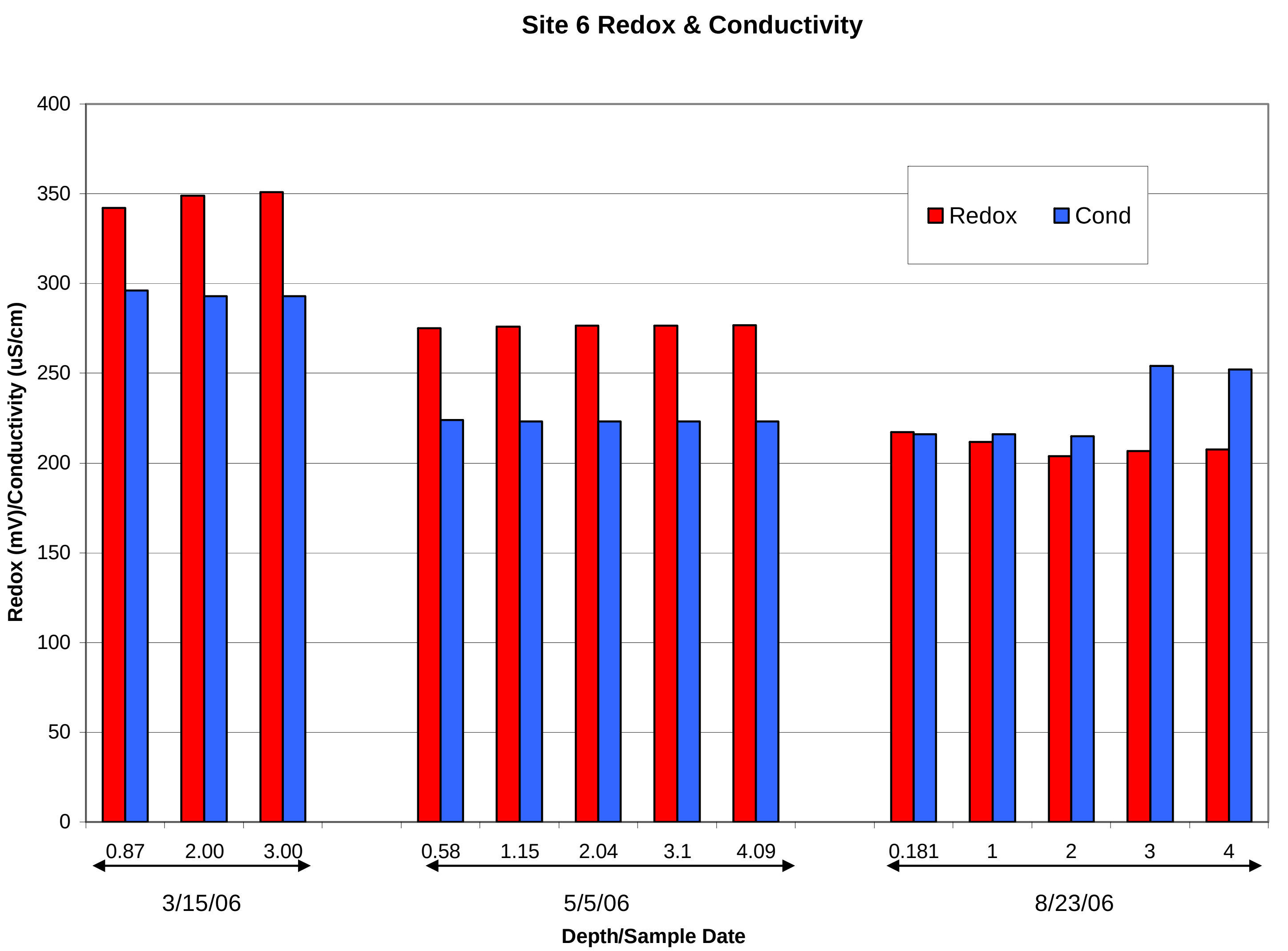

Site 2
Redox & Conductivity
3/15/05
Redox
Cond
340
339
338
337
336
335
334
333
252
250
248
246
244
242
240
238
Redox (mV)
Conductivity (uS/cm)
0.60
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
Depth (M)

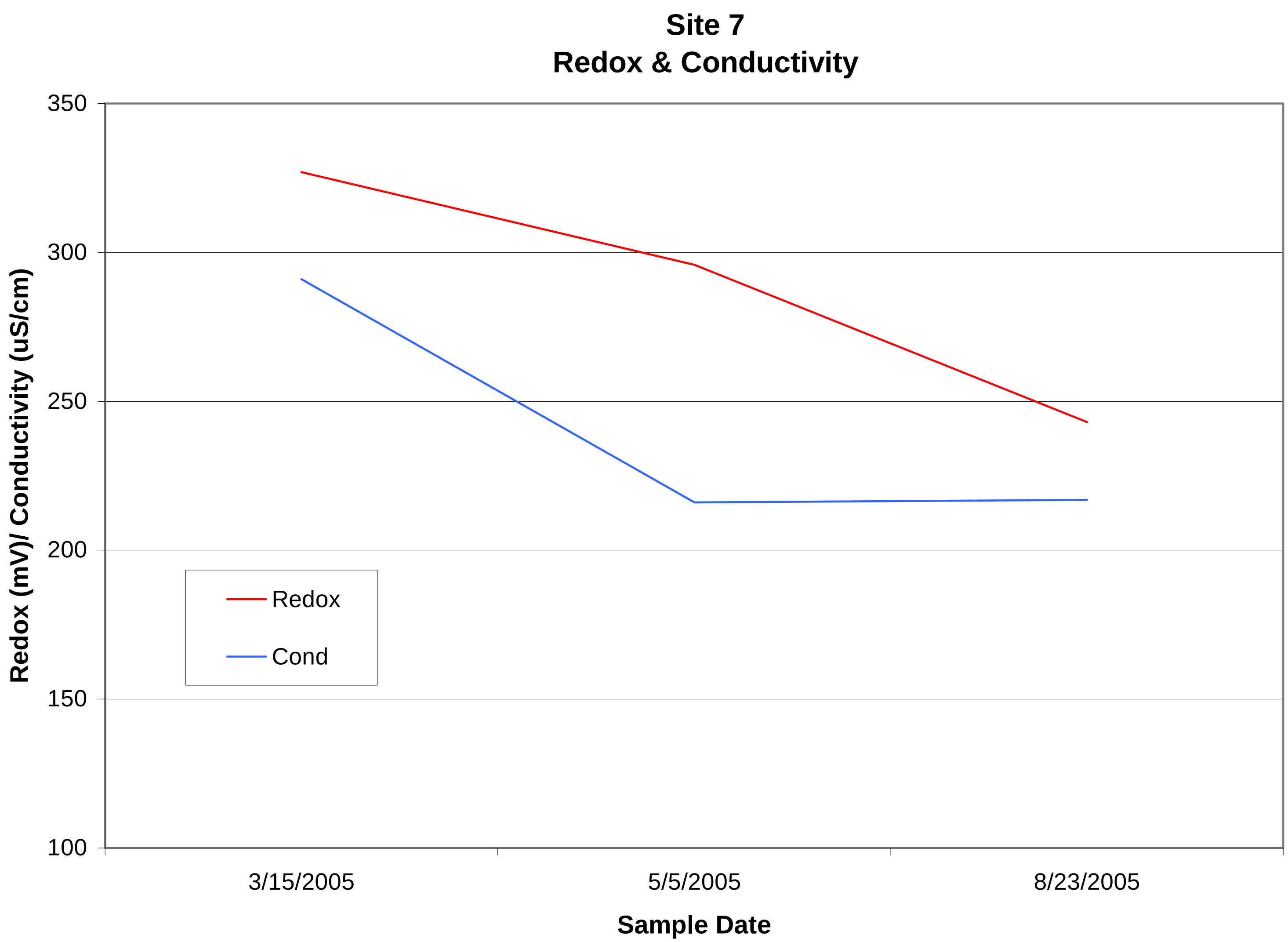

Site 2
Redox & Conductivity
5/5/05
Redox
Cond
Redox (mV)
250
200
150
100
50
0
0.67
1.67
2.17
3.1
4.09
5
6.2
7.15
8.02
9.1
10.36
Depth (M)

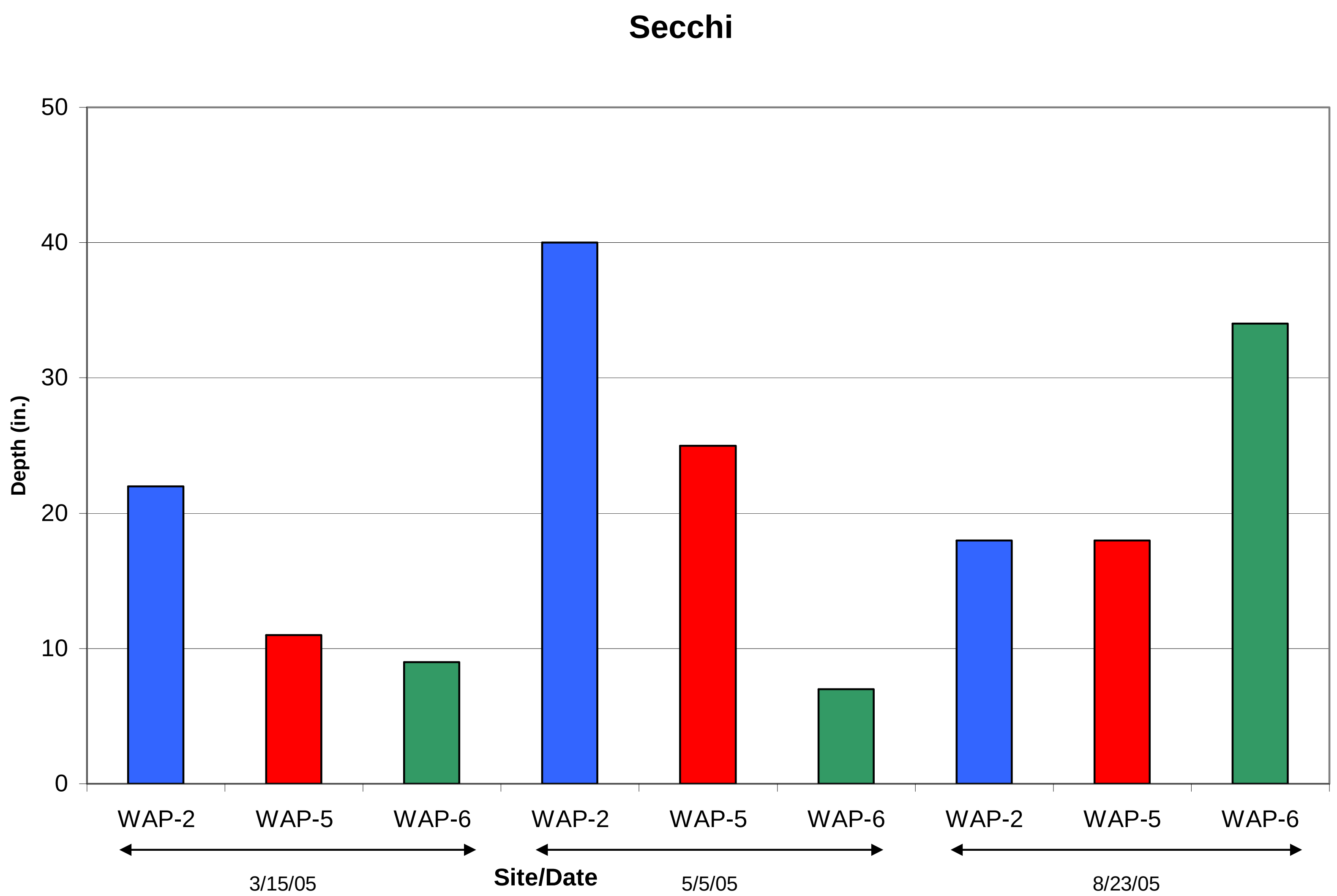

Site 2
Redox & Conductivity
8/23/05
Redox (mV)
450.0
350.0
250.0
150.0
50.0
-50.0
-150.0
-250.0
-350.0
Redox
Cond
0.013
1
2
3
4
5
6
7
8
9
10
Depth (M)



Site 5
Redox and Conductivity
Redox
Cond
Redox (Mv)
400
350
300
250
200
150
100
50
0
0.67
1.00
2.00
0.4
1
2
3.1
4.39
0.17
1
2
3
3/15/06
5/5/06
8/23/06
Depth (m)/Sample Date


Site 6 Redox & Conductivity
Redox
Cond
400
350
300
250
200
150
100
50
0
Redox (mV)/Conductivity (uS/cm)
0.87
2.00
3.00
0.58
1.15
2.04
3.1
4.09
0.181
1
2
3
4
3/15/06
5/5/06
8/23/06
Depth/Sample Date


Site 7
Redox & Conductivity
Redox (mV)/ Conductivity (uS/cm)
350
300
250
200
150
100
Redox
Cond
3/15/2005
5/5/2005
8/23/2005
Sample Date


Secchi
50
40
30
20
10
0
Depth (in.)
WAP-2
WAP-5
WAP-6
WAP-2
WAP-5
WAP-6
WAP-2
WAP-5
WAP-6
3/15/05
Site/Date
5/5/05
8/23/05